

10 NO-COST PC upgrades

apc

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CHRISTMAS 2020 #488

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GUIDE TO
MECHANICAL
KEYBOARDS

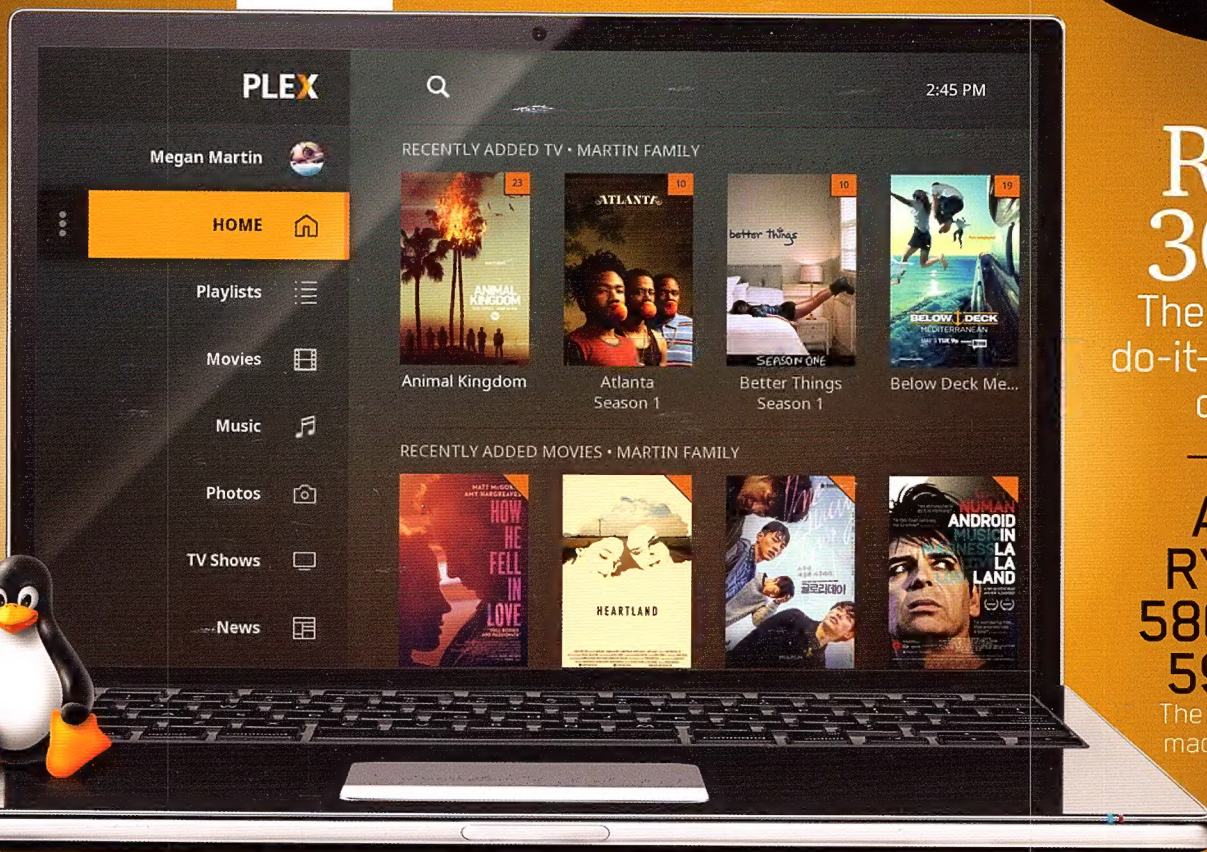
RTX
3070

The perfect
do-it-all gamer
card?

AMD
RYZEN
5800X &
5950X

The CPUs that
made Intel #2

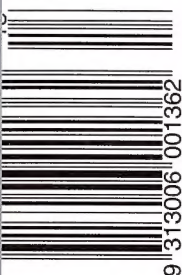
OS
COST?
FREE!



Build the **ULTIMATE** Media Server

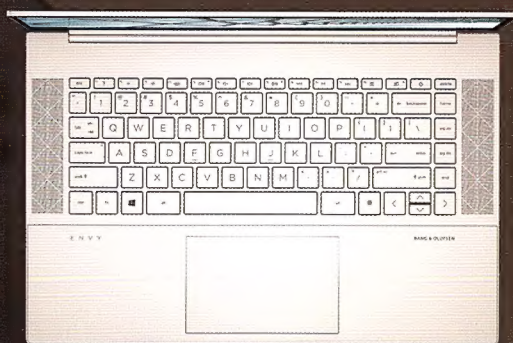
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REVIEWED
**Dell XPS
13 & HP
Envy**

THE MOST DESIRABLE
LAPTOPS ON
THE PLANET



HEAD-TO-HEAD
**AUDACITY vs
AUDITION**
BEST AUDIO WORKSHOPS

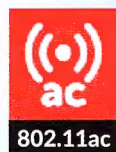
PC BUILDING GUIDE
**Liquid cooling
masterclass**

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- Two USB 2.0 ports for connection to two 3G/4G LTE USB modems, FTP server, network printer and thermometer
- 5 x Gigabit LAN ports with multiple subnets and 60,000 NAT sessions
- 50 x VPN tunnels (including 25 x SSL-VPN tunnels) with comprehensive secure protocols
- Fast VPN throughput, VPN load-balancing and backup for site-to-site applications
- 16 x VLANs for secure and efficient workgroup management
- IPv6 & IPv4
- Up to 1022 IP addresses and 8 IP subnets
- Integrated IEEE 802.11ac (AC1300) wireless Access Point; dual band; up to 867 Mbps throughput (ac/Vac model)
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- Object-based SPI Firewall and CSM (Content Security Management) for network security
- Supports VigorACS 2 and VigorACS 3 Central Management Systems for remote management
- SD WAN capability when used with VigorACS 3
- Central VPN Management for 8 remote Vigor routers
- Central AP Management for deployment of 20 VigorAP's
- Central Switch Management for 10 VigorSwitches
- 2 years back to base warranty

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- Multi-WAN with 1 x GbE WAN port, 1 x configurable GbE WAN/LAN port, 1 x USB port, 2 x 4G LTE SIM slots, and 2 x Wi-Fi WANs for ac model
- 1 x Gigabit Ethernet WAN port and 1 x configurable GbE WAN/LAN port for Failover, Load-Balancing and High Availability mode
- 1 x USB 2.0 port for connection of 3G/4G LTE USB modems, FTP server, network printer and thermometer
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i-LAN Technology Pty Ltd trading as DrayTek Aust & NZ

www.i-lan.com.au

(02) 9838 8899

sales@i-lan.com.au

www.draytek.com.au

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SUBSCRIPTION ENQUIRIES:

(02) 8227 6486, future@crmaus.com.au

Editorial

Editor: **Ben Mansill** ben.mansill@futurenet.com

Senior Journalist: **Shaun Prescott**

Journalist: **Joel Burgess**

Journalist: **Harry Domanski**

Journalist: **Stephen Lambrechts**

Journalist: **Sharmishta Sarkar**

Creative Director: **Troy Coleman**

Designer: **Sharnee Swinnerton**

Contributors

Dave Alcock, Jonni Bidwell, Alex Blake, James Davenport, Ian Eyenden, Kenny Hemphill, Luke Kemp, Carrie Marshall, Rob Mead-Green, Dave Meikleham, Les Pounder, Nick Ross, Shashank Sharma, Anton Shilov, Zac Storey, Chris Szweczyk, Mark Williams, Luke Winkie, Darren Yates, Robert Zac

Photography

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Advertising

Group Advertising Manager: **Cameron Ferris**
cameron.ferris@futurenet.com

Management

Managing Director: **Neville Daniels**

Sales Director: **Paul Marttila**

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Future Publishing Australia

PO Box 1077 Mount Street,
North Sydney, NSW 2059

Tel: (02) 9955 2677 Fax: (02) 9955 2688

Email: apcmag@futurenet.com

Web: www.apcmag.com

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EDITORIAL

Upwards!

The numbers, they go up.

It's all go in the usual places. AMD finally takes the absolute lead in CPU performance over Intel, after its boffins worked to find a 20 percent uplift in single-core performance with the new Zen-3-based 5000 Series CPUs, and we have Chris on the case in this issue with his Ryzen 5800X and 5950X reviews. Single-core was the only remaining area of performance where Intel still held on to a slim lead, so now we look to sometime in early 2021 for Blue's response in the form of its new-architecture Rocket Lake CPUs. Fun times!

Also interesting to see was just how impressive Intel's first showing of its new Xe graphics processing architecture was, which we were able to test in the new Dell XPS, reviewed this issue – and it's always so exciting to see a new XPS. Very pleasingly, this particular integrated Intel Iris Xe – which is part of the Intel Core i7-1165G7 CPU that our review XPS sported – delivered around double the performance of the last gen Iris graphics, so that all bodes well for the future of the Xe architecture. Xe will see its way into data crunching servers, and, later, as a discrete graphics card for PC gaming.

We've been waiting a long time, a very long time, for Intel to finally leave the laboratory with its many previous attempts at a discrete GPU. Anyone remember Larrabee? That was as close as Intel came to actually finishing off a graphics card research adventure and releasing it as a product in recent times. Now that we've seen what Xe can do – in one early form, at least, the overall potential of it looks pretty interesting for the future.

A graphics card we do have in the Labs right now is Nvidia's keenly-awaited RTX 3070. We've previously reviewed the RTX 3080 enthusiast card, as well as the king of the hill, completely ridiculous RTX 3090, but it's the 3070 that most people will buy. Or will they? Or, I should say, *should* they? Chris has the 3070 numbers in his Labs review this month, and it's truly quite the stonker, delivering 2080 Ti performance at half the price. All sounds good, doesn't it? Hang in there, though, shoppers, sit on that wallet a little longer, because we've got a review of AMD's Radeon 6000 coming next month, and all indications are that AMD may be about to do to Nvidia what it did to Intel – delivering as-good or better performance, at a cheaper price.

Amazing. This is exactly what the market needs to drive performance up, and prices down!
BEN MANSILL



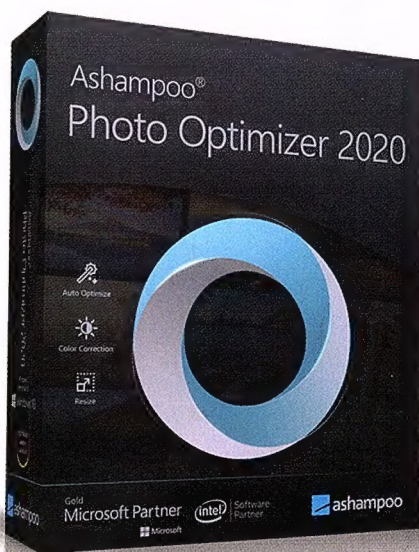
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Full version worth \$52

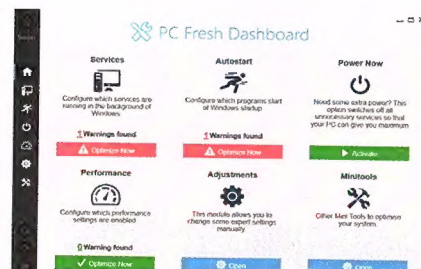
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PC Fresh optimises computers – and now file associations too! Windows does what it pleases – and that's usually far too much. PC Fresh cuts the fat off, ending unnecessary Windows services, pruning startup programs, and resolving system slowdowns. Additionally, the software finds lost application serial numbers hidden on the system and allows the user to customise various aspects of Windows. PC Fresh includes, also, a manager for easily assigning file associations (e.g. opening .txt files with WordPad).

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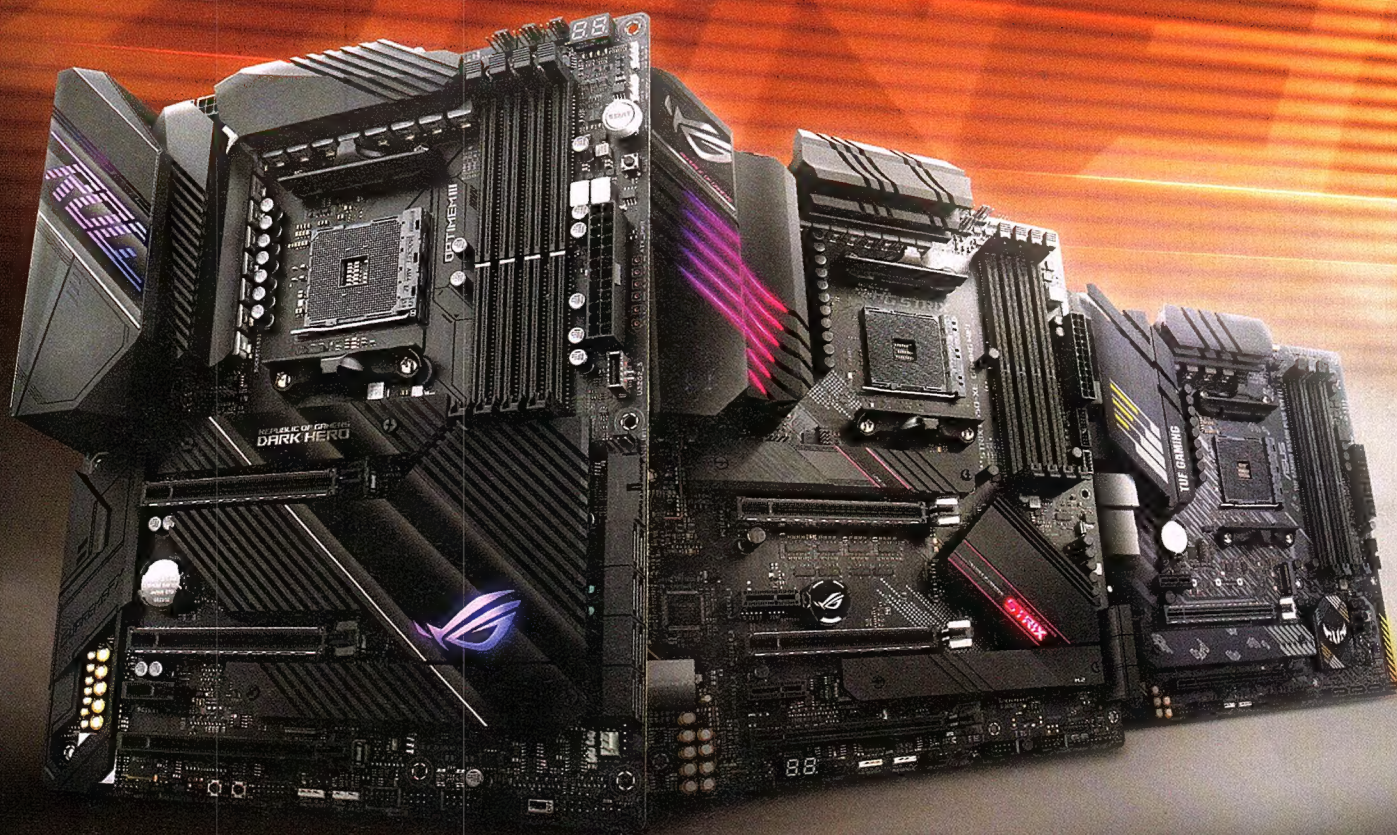
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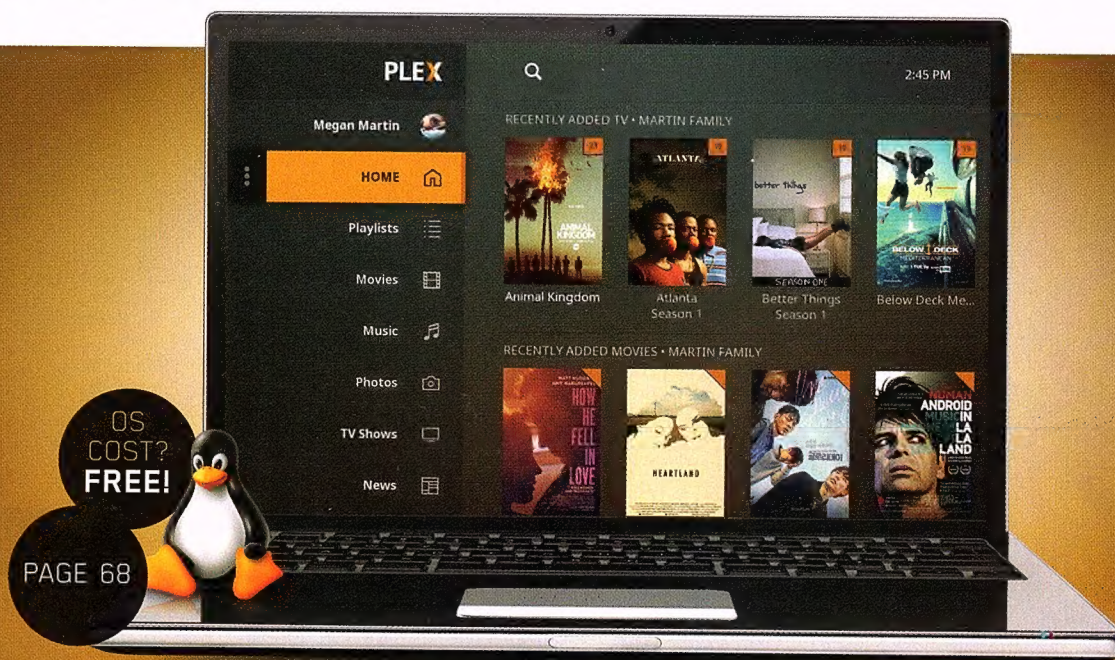
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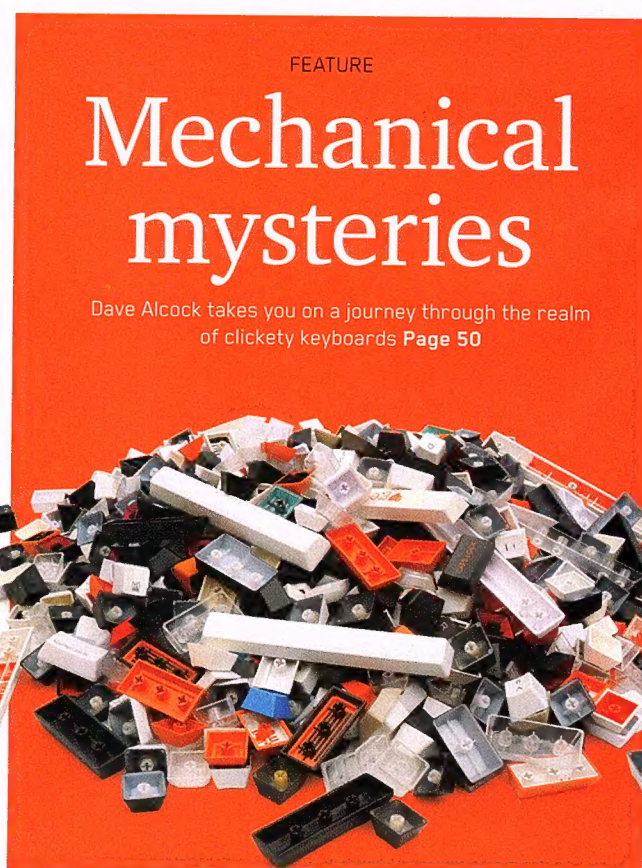
Store and stream your videos, music and photos
with a **FEATURE-RICH HOME SERVER**



FEATURE

Nano liquid cooling

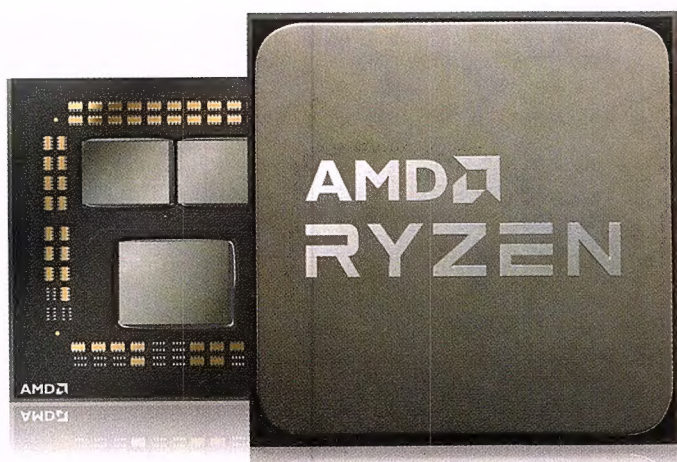
We get hands-on with one of the world's most advanced liquid coolants **Page 58**



FEATURE

Mechanical mysteries

Dave Alcock takes you on a journey through the realm of clickety keyboards **Page 50**



"The 5800X has killed Intel's gaming leadership narrative. It doesn't make gaming on Intel irrelevant by any stretch, but if you add the other strengths including energy efficiency, multi-threaded performance and platform feature advantage, then it's a clear winner."

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YOUR EXPERT GUIDE TO TODAY'S TECH

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THE HOTTEST GEAR LABS TESTED

Build the **ULTIMA** Media Server

Store and stream your videos, music with a FEATURE-RICH HOME SERVER

REVIEWED **Dell XPS 13 & HP Envy**

THE MOST DESIRABLE LAPTOPS ON THE PLANET

apc **GeForce RTX 3070 Founders Edition**

Amey's impressive gains

APC **GeForce RTX 3070 Founders Edition**

Amey's impressive gains

Model	Price	Value	Score	Price/Score
Nvidia GeForce RTX 3070 Founders Edition	499	74	8,796	118.75
ASUS ROG Strix GeForce RTX 3070	549	74	8,853	120.45
MSI GeForce RTX 3070	549	72	8,524	118.25



APC HOT PRODUCT

When a reviewed product scores 4.5 out of 5 or higher, it carries the Hot Award. These are products that exceed expectations and deliver a quality experience up there with the very best.



APC RECOMMENDS

You will see this award if a reviewed product has scored four out of five stars. It means most people can expect satisfying performance from the product, and that we would use it ourselves.

Inside APC

Find out all about APC's editorial policies, test practices, how to read the benchmark results, and more.

APC is Australia's oldest consumer technology magazine – having been consistently in print for forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And, like you, APC's journalists want to know what's good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and APC aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in APC are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an APC reviewer has any potential conflicts of interest involving a

brand, the review will always be assigned to another writer.

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

In most cases, for the benchmark results published in APC, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred.

“APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible.”



FRITZ!Repeater 300



FRITZ!Box 7590



FRITZ!Box 7530



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An intelligent
system for
consistently
strong signal



Easy and flexible
to expand



One network
for all devices



DSL, telephony
and Smart
Home on
board



Easy to use and
smart apps

Wi-Fi at home is the best! But it's not so great when reception is weak in some rooms. The solution? Mesh networking at home with FRITZ!.

The FRITZ!Box 7590 or 7530 and FRITZ!Repeater 300 is the perfect solution for medium-size apartments/houses on one to two floors

Pic: AMD



AMD in US\$35 billion all-stock acquisition of Xilinx

Now a major player in the FPGA market.

As we speculated last month in *APC*, AMD has gone feet first into a full acquisition of FPGA manufacturer Xilinx. The deal involves an all-stock transaction, leveraging AMD's sizeable share price in order to enable an equivalent US\$143 per Xilinx share – current AMD stockholders will still own 74% of the combined company, while Xilinx stockholders will own 26 percent. The combined US\$135 billion entity will total 13,000 engineers, and expand AMD's total addressable market to US\$110 Billion.

It is believed that the key reasons for the acquisition lie in Xilinx's adaptive computing solutions for the data centre market. As part of the acquisition, Victor Peng will join AMD as president responsible for the Xilinx business, and at least two Xilinx directors will join the AMD Board of Directors upon closing.

Pic: SK Hynix



SK Hynix to buy Intel's NAND memory business

But hanging onto Optane.

In a joint press release, SK Hynix and Intel have announced that Intel will be selling the entirety of its NAND memory business to SK Hynix. The deal, which values Intel's NAND holdings at US\$9 billion, will see the company transfer over the NAND business in two parts, with SK Hynix eventually acquiring all IP, facilities, and personnel related to Intel's NAND efforts.

Notably, however, Intel is not selling its overarching Non-Volatile Memory Solutions Group; instead the company will be holding on to its Optane memory technology as it continue to develop and sell that technology. This will see Intel's consumer and enterprise SSD businesses transferred to SK Hynix, along with the relevant IP and employees for the SSD business, but not any NAND IP or employees.

CPU NEWS

Intel's discrete GPU era begins

Iris Xe Max for entry-level laptops launches.

Almost a year after showing off its alpha silicon, Intel's first discrete GPU in over two decades has been released and is now shipping in OEM laptops. The first of several planned products using the DG1 GPU, Intel's initial outing in its new era of discrete graphics is in the laptop space, where it is launching its Iris Xe MAX graphics solution. Designed to complement Intel's Xe-LP integrated graphics in the new Tiger Lake CPUs, Xe Max will be showing up in thin-and-light laptops as an upgraded graphics option, and with a focus on mobile creation.

The company has continuously been coy about the product, but at a high level it's been clear for some time that this was going to be an entry-level graphics solution suitable for use in smaller laptops. Based heavily on the integrated graphics in Intel's Tiger Lake-U CPU, the Xe-LP architecture GPU is a decidedly entry-level affair. None the less, it's an important milestone for Intel: by launching its first DG1-based product, Intel has completed a first step in its plans to establish itself as a major competitor in

the discrete GPU space.

To cut right to the chase on an important question for our more technical readers, Intel has not developed any kind of multi-GPU rendering technology that allows for multiple GPUs to be used together for a single graphics task (ala Nvidia's SLI or AMD's CrossFire). So there is no way to combine a Tiger Lake-U iGPU with Xe Max and double your *DOTA* framerate, for example. Functionally, Xe Max is closer to a graphics co-processor – literally a second GPU in the system. As a result, Intel isn't seriously positioning Xe Max as a gaming solution.

The launch of Intel's Xe Max graphics and the DG1 GPU is an important step for Intel, but this is also a launch that strikes us as Intel having modest expectations. Xe Max is only being launched in a small number of laptops for now, and Intel is not seriously chasing the gaming market with its first discrete laptop part. None the less, it will be interesting to see what kind of traction Intel can get as a new player in the market.

"The company has continuously been coy about the product, but at a high level it's been clear for some time that this was going to be an entry-level graphics solution suitable for use in smaller laptops."

	IRIS XE MAX DG1	TIGER LAKE iGPU	ICE LAKE iGPU	KABY LAKE iGPU
ALUS	768 (96 EUS)	768 (96 EUS)	512 (64 EUS)	192 (24 EUS)
TEXTURE UNITS	48	48	32	12
ROPS	24	24	16	8
PEAK CLOCK	1650MHZ	1350MHZ	1100MHZ	1150MHZ
THROUGHPUT (FP32)	2.46 TFLOPS	2.1 TFLOPS	1.13 TFLOPS	0.44 TFLOPS
"GEOMETRY RATE (PRIM/CLOCK)"	2	2	1	1
MEMORY CLOCK	LPDDR4X-4266	LPDDR4X-4266	LPDDR4X-3733	DDR4-2133
MEMORY BUS WIDTH	128-BIT	128-BIT (IMC)	128-BIT (IMC)	128-BIT (IMC)
VRAM	4GB	SHARED	SHARED	SHARED
TDP	-25W	SHARED	SHARED	SHARED
MANUFACTURING PROCESS	INTEL 10NM SUPERFIN	INTEL 10NM SUPERFIN	INTEL 10NM	INTEL 14NM+
ARCHITECTURE	XE-LP	XE-LP	GEN11	GEN9.5
GPU	DG1	TIGER LAKE INTEGRATED	ICE LAKE INTEGRATED	KABY LAKE INTEGRATED
LAUNCH DATE	11/2020	09/2020	09/2019	01/2017



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DRIVE YOUR GAME

Pic: Western Digital



Western Digital's Ultrastar DC ZN540 is the world's first ZNS SSD

Can replace four conventional SSDs.

Western Digital is one of the most vocal proponents of the Zoned Namespaces (ZNS) storage initiative, so it is not surprising that the company became the first SSD maker to start sampling of a ZNS SSD. When used properly, the Ultrastar DC ZN540 drive can replace up to four conventional enterprise SSDs, provide higher performance and improve quality of service (QoS).

ZNS SSDs have a number of advantages over traditional block-based SSDs. For one, they place data sequentially into zones and have better control over write amplification, since the software 'knows' what it is dealing with. This means that ZNS SSDs don't need as much overprovisioning as traditional enterprise drives. It's unclear at this stage if the tech will make it to consumer SSDs.



Support ends for Windows 10 version 1809

Extended support period over.

Official support for the Windows 10 Home or Pro editions of Windows 10 version 1809 has now ended. Originally set to fall out of support in May, Windows 10 version 1809 is officially out of support after November 10. Microsoft extended support for Windows 10 version 1809, also known as the Windows 10 October 2018 Update, to ease the transition to newer versions of Windows 10 during the current global pandemic.

Usually, versions of Windows 10 only get 18 months of support, but Microsoft extended support in case people didn't want to upgrade during the first few months of lockdowns caused by the current global pandemic. Out of support operating systems no longer receive security updates, so staying on a supported version is important.

MAC NEWS

Apple announces first computers with M1 processors

MacBook Air, 13-inch MacBook Pro and Mac Mini get Arm-based processors

Apple has taken its first steps to move its Mac computers onto its own Arm-based processors and starting its two-year transition away from CPUs from Intel. Apple announced the MacBook Air, 13-inch MacBook Pro and Mac Mini with the new M1 chip, which can be ordered now.

John Ternus, VP of hardware engineering, detailed the transition to the "next generation of Mac," coming over the next "couple of years."

The first chip is the M1, which Apple's chip lead Johny Srouji said would create a "completely different class of product. It would replace the separate chips for the CPU, I/O, and more. It also includes memory on the chip. It's a 5nm chip with 16 billion transistors. It has eight cores, four for power and four for efficiency. Srouji said the high-performance cores are the world's fastest and deliver the best performance per watt. It has a 10W thermal envelope.

Additionally, Srouji detailed the chip's integrated graphics, an 8-core GPU with 128 compute units. He said it's the world's fastest integrated graphics. There's also a

16-core neural engine for machine learning. It also houses the Secure Enclave for security.

Apple also detailed the first Macs with M1. The first is the MacBook Air, starting at \$1,599. It has a 3.5x faster CPU in the M1, which was being compared to an Intel Ice Lake processor. Apple also claimed a 5x improvement in integrated graphics. The design has no fan, so it can run silently. Apple is also promising 15 hours of wireless web browsing and 18 hours of video playback, claiming the longest battery life of any MacBook Air.

The MacBook Pro will get the M1, starting at \$1,999. Apple is claiming faster performance than ever on the CPU, with a GPU up to five times faster over previous 13-inch MacBook Pros. Unlike the MacBook Air, the Pro has active cooling. Apple claims that the battery life goes up to 17 hours of web browsing and up to 20 hours of video playback, for the longest battery life ever on a Mac.

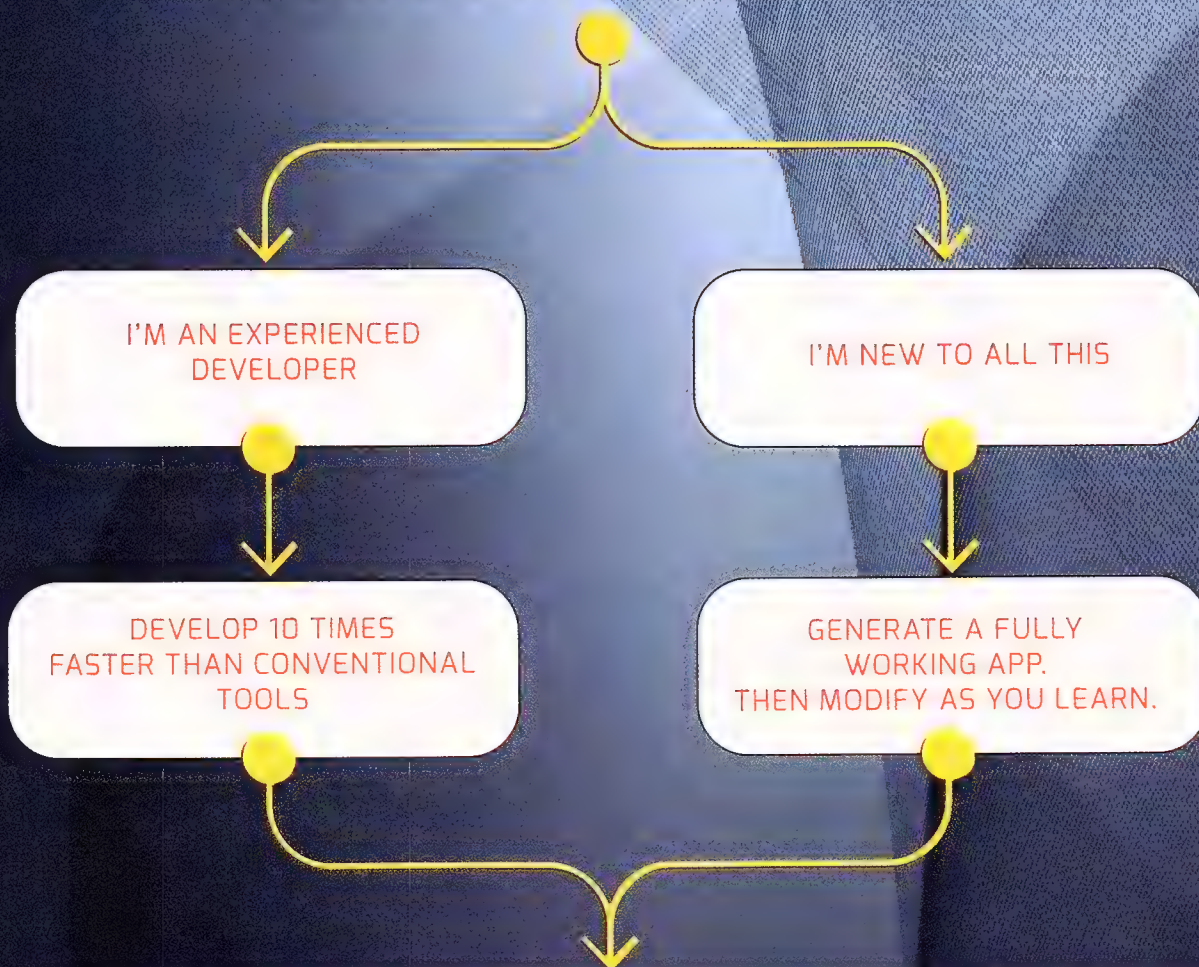
APC is chasing down review samples of these interesting new laptops, and we hope to bring you an in-depth look as soon as we can. ■

"It would replace the separate chips for the CPU, I/O, and more. It also includes memory on the chip. It's a 5nm chip with 16 billion transistors. It has eight cores, four for power and four for efficiency."

Pic: Apple



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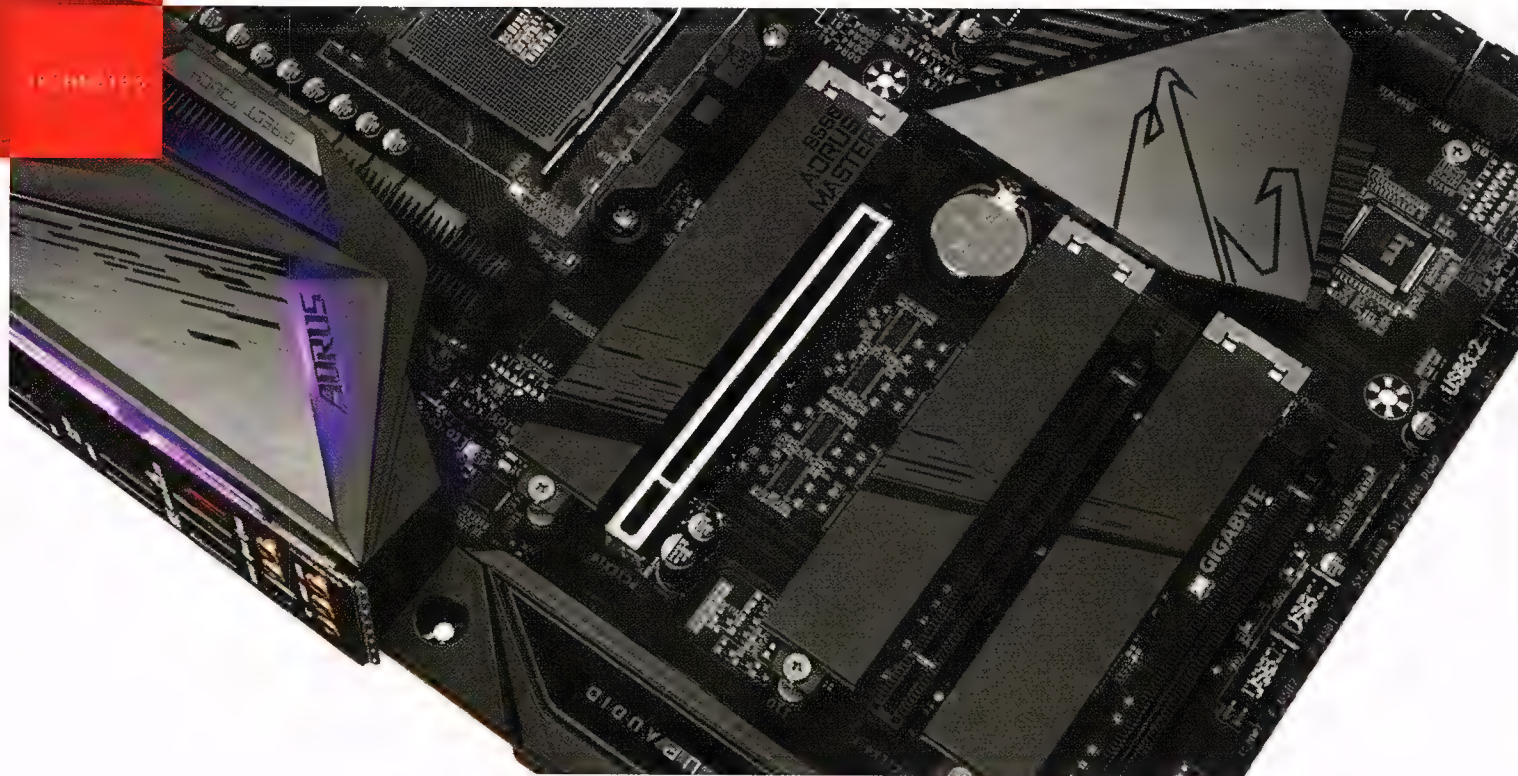
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TECH BRIEF

PCIe 6.0 specification hits milestone

64 GT/s & PAM4 encoding on-track for 2021 finalisation.

The PCIe 6.0 technology achieved an important milestone in November, as PCI-SIG released version 0.7 of the specification. The release of the new 'complete draft' specification indicates that the technology has been defined and its electrical specifications have been validated using test chips. Essentially, it means that PCIe 6.0 is ready and functional, so it is only a matter of time before it is finalised sometime in 2021.

PCIe 6.0 will increase data transfer rate to 64 GT/s per pin, up from 32 GT/s in case of PCIe 5.0 and 16 GT/s in case of PCIe 4.0. In a bid to increase data transfer rate and bandwidth, the new interface adopted pulse amplitude modulation with four levels (PAM4) signalling, which is also used for high-end networking technologies like InfiniBand as well as GDDR6X memory. In addition, PCIe 6.0 uses low-latency forward error correction (FEC) to ensure high efficiency. In general, PCIe 6.0 is a major step forward for the interface and since it introduces a number of innovations, in a bid to bring it to the market on time a

very disciplined execution on the standard development is required.

The release of the PCIe 6.0 spec version 0.7 is a particularly important one since after this release no new features can be added and electrical specifications of the technology have been validated using test chips. In fact, at this stage, various companies may have actual implementations of the new bus ready (but not necessarily announced).

Each PCI Express specification (just like any other spec designed by PCI-SIG) features five primary checkpoints:

- Version 0.3: Concept. This draft describes general goals and approaches that will be used to achieve them. As far as PCIe 6.0 is concerned, these general things are 64 GT/s data transfer rate, PAM4 signaling, and FEC.
- Version 0.5: the First Draft. This release must fully address the goals set in the draft 0.3, it also includes all architectural aspects and requirements. Furthermore, it contains feedback from various interested parties and at this

point members of PCI-SIG can add capabilities to the specification being developed.

- Version 0.7: the Complete Draft. This version must have a complete set of functional requirements and methods defined because no new features can be added after this release. Furthermore, electrical specifications must have been validated using test chips. At this point, it is possible for PCI-SIG members to propose different implementations of a new interface.
- Version 0.9: the Final Draft. At this point PCI-SIG members are performing internal reviews of the technology for their intellectual property and patents. Meanwhile, no functional changes are permitted.
- Version 1.0: the Final release. Starting from this version, all changes and enhancements have to go through errata documentation and engineering change notices (ECNs).

If PCI-SIG finalises the PCIe 6.0 technology in the second half of 2021 (a year from now sounds more likely, but we are speculating), expect supporting platforms to arrive sometime in late 2023 or in 2024.

ANTON SHILOV ■

"PCIe 6.0 will increase data transfer rate to 64 GT/s per pin, up from 32 GT/s in case of PCIe 5.0 and 16 GT/s in case of PCIe 4.0."

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END USER

Microsoft has brought game streaming to Australia, but where is everyone else?

The country's lagging internet infrastructure will be put to the test with xCloud, writes Shaun Prescott.

Last month, much to the surprise of all, Microsoft rolled out the Project xCloud beta in Australia. The company's Xbox department head, Phil Spencer, had already made a vague promise that it would hit the antipodes some time in 2021, but at the time even that seemed unlikely. Game streaming in Australia? It's just not a *thing*.

Look at all the services that have skipped Australia so far. Sony's PlayStation Now service, a cloud gaming subscription service that launched in North America in 2014, is still a no show in Australia, with no sign of a rollout anytime soon. Google Stadia was marketed much more heavily than Sony's service in the lead up to its 2019 release, but on the question of an Australian rollout Google has stayed quiet. GeForce Now? Don't even ask.

It's not that it's impossible: Google Stadia can stream 1080p HDR video at 60fps on a connection that can reach (and hopefully comfortably exceed) 20Mbps. If you suffer a mere 10Mbps (it's not rare!) you can still theoretically stream at 720p with 60 frames per second. Of course, for 4K you'll need an out-of-reach-for-many 35Mbps minimum.

According to the September 2020 [speedtest.net](https://www.speedtest.net) report (a great site for checking your own speeds), the average Australian fixed broadband internet speed is 55.97Mbps. We come in *just* behind Vietnam (56.83) and way behind countries like Brazil, Moldova, Malta, Hungary... the list is 55 countries long. For reference, Singapore's average speed wins at 226.60Mbps, while the United States comes in at



SHAUN PRESCOTT
Author, PC gamer and passionate technology observer, Shaun covers trending tech topics for APC.

tenth position with 161.14Mbps.

Yeah, our situation isn't great, but if you have a good internet connection in Australia you'll comfortably fit within Google's own streaming guidelines - you can probably even stream at 4K. At the time of writing, we haven't had the chance to test xCloud in Australia - our mag went to print just days before its launch. That said, Microsoft itself claims the *minimum* requirement is 10Mbps, whether on a mobile connection or with 5GHz Wi-Fi. Since the xCloud beta is only compatible with Android tablets and phones, depending on your data cap, you'll probably want to be connected to Wi-Fi when testing it.

If you're lucky to have an NBN connection or have an NBN50 connection, in theory a game streaming service shouldn't be impossible. Carriers like Vodafone and Dodo advertise a 40Mbps "typical evening speed" (ie, you'll probably get higher speeds outside of those busy hours) but it's the reliability that really matters. Anecdotally, I use an NBN25 connection and even during the day, my connection can fall to around 15Mbps download, depending on the whims of the internet gods.

Whatever the case, xCloud's move in Australia is a welcome one, if we're ever to see this burgeoning market grow (or even exist) down here. And it makes good business sense: Microsoft is aggressively bolstering its subscription-based gaming models. When xCloud launches properly in 2021, you'll get it free with an Xbox Game Pass Ultimate subscription. Microsoft's ecosystem may not be as ubiquitous and inescapable as Google's, but there's no denying it has the credentials when it comes to gaming. ■

"According to the September 2020 speedtest.net report, the average Australian fixed broadband internet speed is 55.97Mbps. We come in just behind Vietnam (56.83) and way behind countries like Brazil, Moldova, Malta, Hungary..."

Project xCloud

[PREVIEW]

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XBOX

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Microsoft

Did Apple just make the world's best mid-range gaming GPU?

If you take its marketing at face value, Apple's new M1 processors inside the new MacBook Pro and Air are the best in the world... But are they *really* – after you unpack the caveats?

When Apple announced that it would drop Intel chips from its range in lieu of in-house designed processors back in June, it created a lot of curiosity around just how successful that first round of silicon would be. In November, when it announced the first Apple M1 SoCs built for PCs, Apple basically said that its first in-house PC processors in 15 years are better than anything else on the market. “The world's fastest CPU core in low-powered silicon, the world's best CPU performance per watt, the world's fastest integrated graphics in a personal computer”, were just some of the lofty claims made by Apple about its M1 chips at launch.

Since we don't have a new 13-inch MacBook Pro at the time of writing, you'll have to wait until next issue to know how well

these claims hold up, but there's a couple of important caveats that are worth pointing out which temper them considerably. The footnote to these claims in Apple's press release doesn't give away a whole lot about the tests Apple used as a foundation for these claims, but it does demarcate that the M1 chip was compared in October 2020 “against the highest-performing integrated GPUs for notebooks and desktops commercially available at the time of testing.” We have a Dell XPS 13 review in this issue (page 33) which uses one of Intel's 11th generation laptop CPUs, and since this laptop was released in the US and Canada on the 1st of October (with local availability arriving in the middle of that month) we can reasonably assume that Apple actually included the new XPS and its Core i7-1165G7 in the



JOEL BURGESS

When not reviewing PCs for APC and writing our funny pages, Joel likes to ponder tech and how it's used.

somewhat vague comparison.

From a CPU perspective, including this processor as a comparison isn't that big of a deal, since it wasn't even the fastest that Intel had in laptops at the time. Even if it was, Apple was only testing for single-core performance (which doesn't necessarily reflect overall processor power) and who knows what Apple means by “the fastest CPU core in low-powered silicon” since low-powered silicon isn't a quantifiable norm.

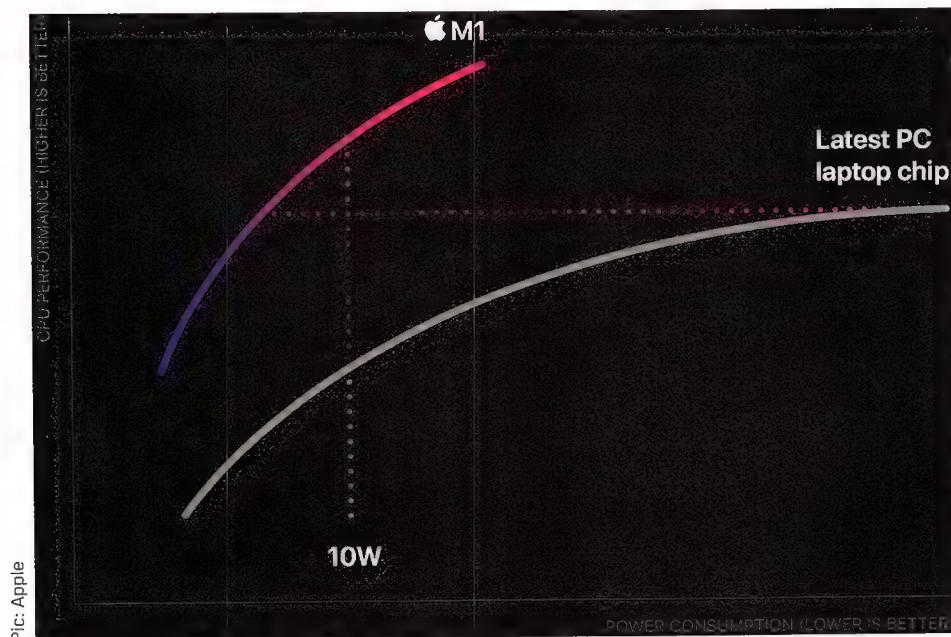
What we are intrigued by, however, is the claim that it has the world's fastest integrated graphics when compared to the Intel Iris Xe Graphics that we've just tested with the latest XPS 13. If you jump over to that review you'll see that Intel has put a lot of effort into bolstering its integrated graphics capabilities. So much so, in fact, that the XPS 13 is actually capable of light 1080p gaming on modern titles if you dial down the graphical presets as far as they go.

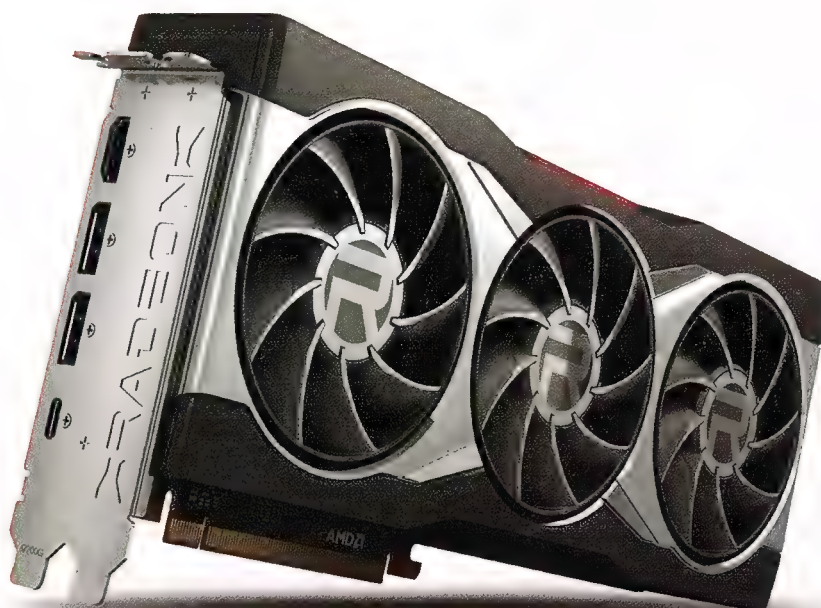
The Intel Iris Xe Graphics on the new XPS 13 perform roughly twice as well as the Intel Iris Plus GPUs on previous generations, and since Apple has stated that its GPUs offer up to up to two times the graphical performance of the latest integrated GPUs, it would make sense that it was only compared to Intel's older Iris Plus processors. But this is in stark contrast to what Apple states in its marketing material.

So basically Apple has either beaten Nvidia, AMD and Intel to make the world's most efficient and best-value mid-range gaming GPU, or it's made some pretty public marketing blunders in claims like “At every power level, M1 delivers significantly higher graphics performance than the very latest PC laptop chip – for up to 2x the graphics speed.”

Check back in next month to see which one it was... ■

“From a CPU perspective, including this processor as a comparison isn't that big of a deal, since it wasn't even the fastest that Intel had in laptops at the time.”





AMD's new Radeon 6000 cards are reportedly absolute monsters for crypto mining.

TWO BITS

Is crypto currency mining making a comeback?

Proof of Stake is the way of the future.

Remember back in 2017, when the average gamer could hardly find a GPU in stock anywhere in the world? Crypto currency mining became a frenzy, with users hoping for massive gains and easy riches. That bubble well and truly burst in early 2018 as most crypto crashed in value. Fast forward to late 2020 and coin values are starting to rise. Bitcoin isn't all that far away from its all-time high, DeFi and sites like Uniswap are all the rage and Wall Street is a little less sceptical of crypto. Are the conditions set for a return to the craziness of 2017?

Mining using CPUs and GPUs is known as PoW, or Proof of Work. It's a proven method for securing and validating transactions, especially for networks with high levels of computational power. These days it's all but impossible to mine Bitcoin with a CPU or GPU, given the capabilities of specially designed mining equipment that's run in football field-sized warehouses

in places like China where there's cheap power. The problem is PoW is shockingly energy inefficient, with Bitcoin mining using more power than some entire countries.

If you've got some solar panels and want to jump in, PoW isn't dead, and it's possible to earn non-trivial amounts of coins like Eth with current GPUs. I would not recommend investing too much in hardware at this point for mining. If you can get superseded cards like the Radeon 5700 or RTX 20-series cards and have access to cheap power, then go for it. But dropping thousands in the hope that it will pay for itself in the future isn't a good strategy. Rumours indicate that AMD RX 6000 cards are computational powerhouses, so there may be some genuine life in GPU mining yet – at least until Eth makes the transition to v 2.0 – which ditches PoW in favour of a rising alternative mining method: PoS, or Proof of Stake.

PoS is a method used validate



CHRIS SZEWCZYK

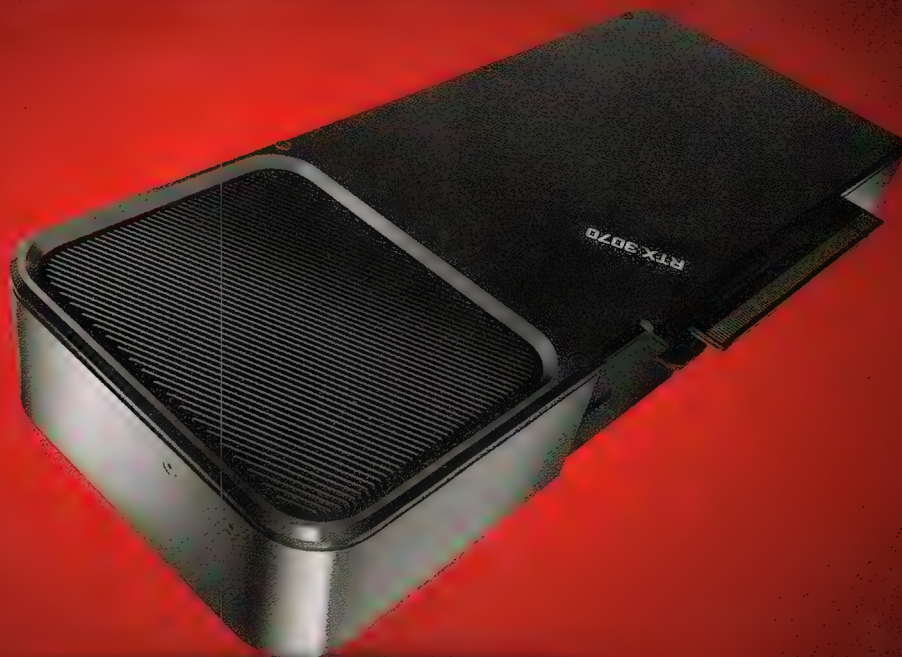
A life-long PC tech enthusiast, Chris has worked across the industry in many areas as a product and technology expert.

transactions according to the number of coins owned. So, the more coin you own, the more likely you are to mine a block and receive a reward. There are pros and cons, but one of the biggest pros is its energy efficiency. A simple NUC or even a Raspberry Pi can be used to mine. A few watts of power consumption is clearly preferable compared to the use of 1000W plus for even a fairly simple home PoW setup.

The trend is towards PoS. So, it might be a better strategy to use mining rig funds and buy certain coins themselves, then run a node on a very basic NUC or low power system and sit back and hope for some rewards. There are hundreds of profitable coins out there, (and a whole heap of rubbish too). With summer here, the last thing you need is half a dozen or more hot GPUs spewing out heat. Do your research.

PoW evangelists will fight on, but with increasing climate alarm, PoS or some variant of it is the way of the future. It's cheaper and simpler, with lower barriers to entry and it incentivises you to hold the coins you own, therefore restricting supply and increasing value. Hold onto that old NUC. It may become a decent little earner one day. ■

"If you can get superseded cards like the Radeon 5700 or RTX 20 series cards and have access to cheap power, then go for it. But dropping thousands in the hope that it will pay for itself in the future isn't a good strategy."



The RTX 3080 and RTX 3090 launches went poorly; can the RTX 3070 fare any better?

TECH TALK

Anatomy of a GPU launch

Getting the stars to align for a perfect launch is difficult at the best of times.

From delays to shortages, price gouging to early driver problems, Nvidia's Ampere launch in 2020 could be the worst GPU launch in its history. It's not that the product is bad – part of the problem is that it's so good. Hopefully, by the time you read this, things will be in a much better state.

Part of the blame goes to the COVID-19 pandemic, naturally. It's an easy scapegoat, but there's no denying its impact on the technology sector. But COVID wasn't the only problem.

When the RTX 3080 officially went on sale on September 17, online stores were met with unprecedented demand. Amazon says it saw more traffic than on Black Friday, if you can believe that. Naturally, supplies of the new wonder-GPU were nowhere near sufficient. Every major retail outlet apparently sold out within seconds, and the servers for multiple sites crashed under the load – Nvidia's own storefront went down. When the dust settled, bots managed to procure many of the sales. Nvidia says it

manually reviewed every order and canceled those that came from bots, as well as only allowing one GPU per buyer. It still wasn't enough, as the RTX 3090 was basically an encore performance one week later.

Nvidia claims it had as much inventory on hand for the Ampere launch as it did for the Turing launch in 2018, but that overlooks the fact that major shortages occurred at the Turing launch. Even for those who did get a new GPU, things were still rough. I experienced crashes during testing of multiple third-party cards prior to the launch. This isn't entirely unheard of, particularly with a new architecture and new drivers, but the initial crashing was far more rampant than I can recall seeing on any prior GPU. Factory-overclocked cards were particularly unstable. Nvidia's 456.55 drivers fixed the crashing issues, about 10 days after the 3080 launch. 10 days of bumpy roads for the few who managed to buy a card isn't the end of the



JARRED WALTON

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

world, but it was one more thing that went wrong.

Now we're waiting for the RTX 3070 to launch, along with AMD's RX 6000 series, the PlayStation 5, and the Xbox Series X. I suspect demand will once again far outstrip supply for all of these, but maybe things will go better than the RTX 3080. Unfortunately, Nvidia's CEO has stated that he expects shortages for Ampere to continue into 2021, so don't hold your breath.

All indications are that Nvidia and its partners aren't intentionally limiting supply; it just takes time to manufacture the GPUs, cards, and even packaging. Speaking of which, there are multiple accounts of stores shipping RTX 30-series cards without packaging, presumably because that part of the supply chain ran into problems. Somewhere down the line, everyone who wants an RTX 3080 – or an RX 6900 XT, PlayStation 5, or Xbox Series X – will be able to buy one. And if you're not among the first wave of people to get the latest and greatest hardware, that just means you're less likely to experience the initial teething problems. Let the early adopters do the beta testing; two months down the road, things will inevitably be better. ■

“All indications are that Nvidia and its partners aren't intentionally limiting supply; it just takes time to manufacture the GPUs, cards, and even packaging.”

HOW IT'S DONE

TAKING THINGS APART AND HAVING A POKE AROUND



When prying the displays off, be careful not to damage them.

A combination of glue and fragile ribbon cables makes this tricky to disassemble.

Microsoft Surface Duo

We hope you didn't expect this one would be easy...

Microsoft reportedly worked on the Surface Duo for six years. We can probably tear it down in less time than that, but with any brand-new form factor, there are no guarantees. Here's hoping the Duo boasts the repairability of recent Microsoft sequels like the Surface Laptop 3 or the Surface Pro X.

Major tech specs

- Two 5.6in AMOLED displays (each 1800 x 1350, 401 PPI)
- Two batteries working in tandem, totalling 3,577 mAh
- A Qualcomm Snapdragon 855 SoC paired with 6GB of DRAM
- 128GB or 256GB Internal Flash Storage
- A 11 MP f/2.0 camera, optimised for both front and rear use
- Wi-Fi-5, Bluetooth 5.0, 4x4 MIMO LTE, and USB-C 3.1 connectivity hardware

Key findings

- It's a non-phone, but the Duo has a removable SIM like other Surface devices. When folded, it undercuts Samsung's original Fold by 7mm (9.8 mm vs the Fold's 17mm).
- The Duo's entire left half bears a striking resemblance to a miniature iPad – big battery, with a sliver of circuit board

snaking around the right side. The right half looks like nothing we've seen – it's almost a solid wall of circuit board, with a little window in the middle for the second battery.

- Opening pick, meet chassis gap. No heat or suction cups necessary yet! This is way too good to be true. And it is. We quickly get bogged down in adhesive and break out the heat gun. Complicating matters, the panels are booby-trapped. Both batteries are stuck to their respective rear panels, and tethered to the rest of the phone via fragile cables. Careful carving through graphene cooling sheets and sticky strips of adhesive does the trick, but we nearly destroy a flex cable that houses some indicator LEDs and connects the earpiece speaker to the circuit board nearby.
- The Duo's hemispheres are connected by two multi-strand interconnect cables routed through the hinges. They remind us more of old-school MacBook display cables than the flat ribbon cables we've seen in other hinges. We're hopeful that this style of cable will be able to hold up to a lot of abuse.
- As for battery replacement.



Unfolded, this "not a phone" is super thin – just 4.9mm. For comparison, the famously so-thin-it-bends iPhone 6 Plus was 7.1mm.

Obstacle 1: Glue. Lots. Obstacle 2: Tri-point screws. Obstacle 3: One battery's connector is pinned underneath the motherboard. As is often the case with Microsoft, it seems like the only way to kill power is to remove the board completely, making any repair a short circuit waiting to happen.

- Next we twist away Torx screws securing the spine and hinges. The two big wings are free to fly away from the central spine. These frames provide a lot of the device's structure and torsional rigidity, helping the two halves open evenly, and provide mounting points for most of the internals.
- Repairability Score: 2 out of 10 (10 is easiest to repair). Displays and back glass covers can be replaced without disassembling other components. Batteries are glued and require extensive disassembly to service. The USB-C port is soldered to the main board. Tri-point screws secure key components. OLED panels are not well protected from prying, yet must be removed for most repairs. Stubborn glue at all entry points complicates any repair attempt. ■

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THE LIST

The best budget peripherals



08

Logitech G203 Lightsync \$48

A compact and affordable mouse with an 8,000 DPI sensor and three-zone RGB lighting, it's a straightforward upgrade from the previous G203 Prodigy.



07

E-Element Z-88 RGB 60% \$70

With a wide selection of Outemu switches, the Z-88 is a slick 60% keyboard that is surprisingly durable thanks to its aluminum top plate.



06

Steelseries Sensei 310 \$95

Not only is it affordable, but the Sensei 310 is also one of the best ambidextrous mice on the market right now. A 12,000 DPI esports sensor sweetens the deal.



05

JLab Audio Talk GO \$90

Compact but effective, the Audio Talk GO has a solid tripod and dual polar patterns, making it a versatile choice for streamers.



04

HyperX Cloud Stinger Core Wired \$92

With a comfortable design and on-headset controls, the wired model of the Cloud Stinger Core is a reliable gaming headset for under \$100.



03

Havit Mechanical Gaming Keyboard From \$37

A simple, cheap selection of mechanical keyboards that nails the aesthetics and delivers solid performance.



02

Razer Kraken X Lite \$67

A refresh of the classic Kraken X with an ultralight aluminum frame. It doesn't sacrifice quality, though, with 7.1 surround sound and a flexible cardioid mic.

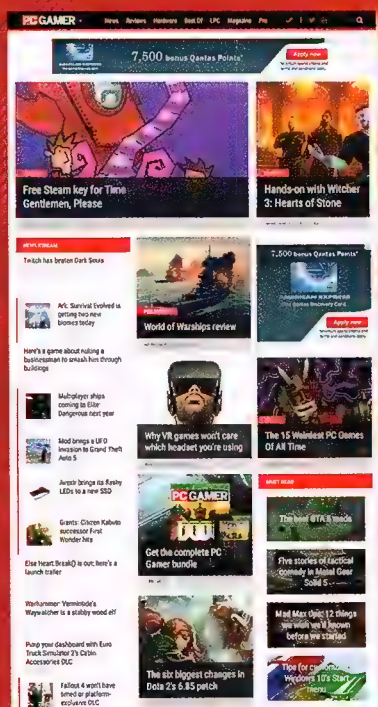


01

HyperX Alloy Core RGB \$92

It's not mechanical, but this is one of the best membrane keyboards we've seen: Feature-rich and super-quiet, with excellent durability to boot. ■

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Harley Davidson Serial 1

Who says you can't have a low emissions low rider?

You might think of a classic Fat Boy when the name Harley Davidson is mentioned, but when you look at the earliest Harley, known as Serial Number One, it actually looks a lot more like a push bike with a motor than a motorbike. In tribute to this original design, Harley

Davidson is releasing an electric bike called Serial 1 that takes naming and design inspiration from the company's earliest design and merges it with the latest in lithium-polymer powered push bike technology. Details are a little thin, but it looks to have a drive belt, an integrated battery and inbuilt tail lights.

\$TBC | press.bmwgroup.com

BMW Motorrad Definition CE 04

This new e-scooter really puts the rad in Motorrad.

If you were excited about Tesla's Cybertruck, but feel like you'll need a better way of earning credits before you can even dream about owning one, BMW may just have the perfect solution. The company unveiled a prototype electric scooter called the Motorrad Definition CE 04 that's got to be one of the coolest looking electric bikes we've seen. Sitting somewhere between an *Overwatch* mount and a bike rover from *No Man's Sky* or *Death Stranding*, whatever it is you'll look like you rode straight out of the future.





\$28 | gskill.com

G.Skill Crystal Crown Keycaps

Pop a cap.

There are a great many key cap sets you can buy to give your keyboard a fresh new face. These ones from memory company G.Skill (not coincidentally G.Skill also sell the most OTT RGB memory kits) are notable for the low low price and the somewhat unique aesthetic, offering a sea of light for your letters, numbers and symbols to float atop. User reports suggest the low cost is because they're cheaply made, though, using a type of plastic that easily takes on a shine after use, and that the printed surfaces are easy to scratch.

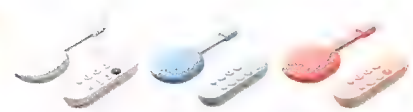


From \$2,699 | www.mate.bike

Mate X

Powered up for all-terrain fun.

As far as e-bikes go, the Mate X is beast. It weighs in at a hefty 30kg of aircraft-grade aluminium, stacked with 20-inch tires that are four inches wide. There's 8-speed Shimano gears, full suspension and disc brakes on both ends. Powering the rear-wheel hub is a 250W, 48V high torque battery that's good for 55-120km range – depending on the level of assist selected (selectable via the smart display attached to the hangers). But let's face it, the more power is better. The bike folds down to 78cm(h)x103cm(l) x59cm(w) which is impractical for taking it on a train, and likely office commuting, but that's OK by us. Its natural environment is off-road, and it's a hell of a lot of fun ripping along firetrails and getting dirty.



\$99 | tv.google

Chromecast with Google TV

A partner agnostic aggregator of your favourite streaming services.

The Chromecast was pretty revolutionary when it first came out, bringing the internet to TVs in the most broadly accessible way yet, so it's nice to see that, three generations on, Chromecast with Google TV builds on that by attempting to aggregate and make searchable all your favourite web streaming apps. In addition to becoming the Google of streaming service catalogues it's also been rumoured that the Chromecast with Google TV will allow you to use your Google Home speakers as a wireless surround sound system. We're not sure if Google's better than Netflix at feeding you the next show you'll love, but at least it'll have the full smorgasbord of content to choose from, so you don't have to keep tabs on all your various subscriptions.

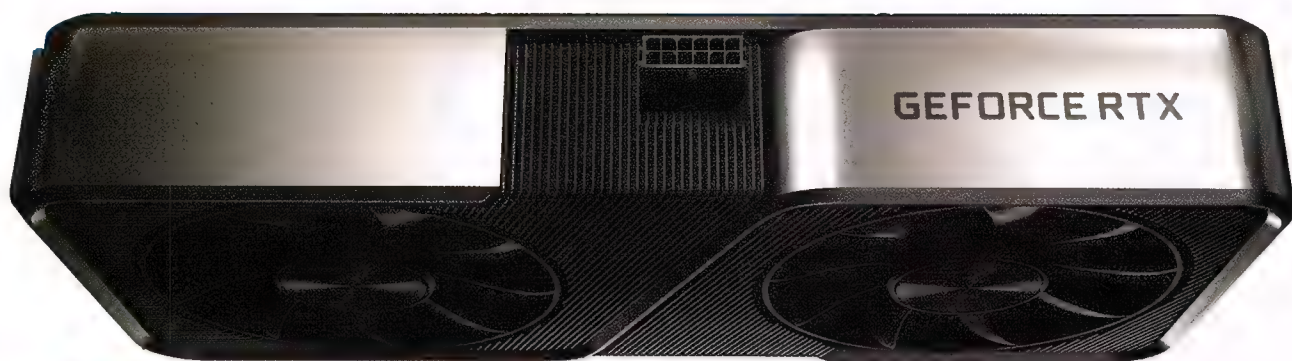


Two-pack \$489 | okmilo.com

Milo

Waterproof walkie talkies for social thrill seekers.

We know that walkie talkies were already a thing in the 1960s, and chances are you haven't used one (or wanted to, really) since you were a kid, but the thought of a wearable waterproof walkie talkie to keep you connected to your friends sounds pretty sweet. With over US\$2.5 million in Kickstarter pre-orders, we guess we weren't the only ones to think this either. Using an efficient mesh network system, the IP67 water resistant device uses a speaker and mic designed to pick up and relay your voice in challenging conditions to keep everyone connected. ■



\$809 | www.nvidia.com

Nvidia GeForce RTX 3070 Founders Edition

Ampere impresses again.

The Nvidia RTX 3070 is the third Ampere card to be released and it's a card we've really been looking forward to. The 3080 really surprised us with its inter-generational performance jump and relative value for money. By most standards though, it's still a very expensive card that's priced out of reach of most gamers. The RTX 3070 though is available for under \$1,000. That's around half the price of the outgoing 2080 Ti. Since the RTX 3070 purportedly offers performance around the 2080 Ti level, that's an incredible doubling of 'frames per dollar'. We have the RTX 3070 Founders Edition on hand for review. Does it deliver on its promise? Of course the RTX 3070 includes all the key Ampere features including improved ray tracing support,

Broadcast, Reflex and G-Sync Ultimate.

The RTX 3070 is the first card built with the GA104 GPU. It packs in 5,888 shader cores running at a boost clock of 1,730MHz. These are joined by 46 Ray Tracing cores and 184 Tensor cores. It's paired up with 8GB of GDDR6 that runs at 14Gbps over a 256 bit bus for a total of 448GB/s of memory bandwidth. The TDP is 220W which is far more palatable than the 350W of many RTX 3080s. It comes with the same single 12-pin power connector found on the 3080 and 3090 FE cards. It still has the rather odd mid card placement that won't impress clean build purists. It's also a questionable requirement at all given that it's effectively an extension cable, with a single 8-pin connector input.

SPECS

Nvidia GeForce RTX 3070 Founders Edition; 5888 Cuda cores; 1500 MHz Base Clock, 1730 MHz Boost Clock; 8GB GDDR6 14 Gbps memory, 448 GB/s Memory Bandwidth; 3x Display Port 1.4a, 1x HDMI 2.1; 1x 12-Pin Power Connector, 220W TDP.

The card itself is very compact and aesthetically simple. It takes up exactly two slots, in terms of both width and height which will appeal to builders of compact systems. Its length matches up perfectly with an ATX motherboard. The cooler is similar to the ones found on the 3080 and 3090 cards, but scaled down size. There are triple DisplayPort 1.4a ports onboard, and a single HDMI 2.1 port with support up to 8K.

What really matters is how it performs, and we're happy to say, the 3070 does a stellar job. We found it to be only slightly behind the RTX 2080 Ti, a card that went for twice the price, so by that measure alone, the 3070 is a fantastic card. It's a perfect high refresh rate 1080p or 1440p card. It's also capable of 4K gaming, though 8GB is starting to be a limiting factor in some games at their most taxing settings.

As we continually note with Nvidia cards, the base clock is all but irrelevant unless you want to run Furmark in a case with zero airflow. Our sample settled into a long term boost clock of between around 1890MHz to 1940MHz at 73 C. At this default setting, we saw the card pull a peak of 227W. This is a full 100W less than the 3080 Founders Edition.

	Temperatures @		3DMark	
	Idle	Load	Time Spy Extreme	Fire Strike Extreme
Nvidia GeForce RTX 3070 FE	32	74	6,756	16,378
Nvidia GeForce RTX 3080 FE	34	74	8,515	20,033
Nvidia GeForce RTX 2080 Ti	36	78	6,815	16,068
Nvidia GeForce RTX 2080 Super	38	72	5,524	13,285

Best result
On test

Best result
On test

	Metro: Exodus						F1 2020					
	1920x1080 Ultra Preset		2560x1440 Ultra Preset		3840x2160 Ultra Preset		1920x1080 Ultra Preset		2560x1440 Ultra Preset		3840x2160 Ultra Preset	
	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg
Nvidia GeForce RTX 3070 FE	53.1	103.1	48.0	81.4	32.5	51.1	168	194	135	155	90	100
Nvidia GeForce RTX 3080 FE	62.6	130.0	57.4	105.9	43.9	68.7	191	218	160	186	112	126
Nvidia GeForce RTX 2080 Ti	55.4	108.6	51.1	85.4	35.1	54.1	171	200	141	161	88	98
Nvidia GeForce RTX 2080 Super	48.5	90.0	42.7	71.6	28.9	44.7	150	175	120	138	75	84

	Middle Earth: Shadow of War						Total War: Warhammer II					
	1920x1080 Ultra Preset		2560x1440 Ultra Preset		3840x2160 Ultra Preset		1920x1080 Ultra Preset		2560x1440 Ultra Preset		3840x2160 Ultra Preset	
	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg
Nvidia GeForce RTX 3070 FE	36	161	30	116	29	71		128.9		97.9		54.6
Nvidia GeForce RTX 3080 FE	36	193	30	156	31	97		155.3		126.0		76.2
Nvidia GeForce RTX 2080 Ti	35	166	36	121	30	75		136.8		101.4		56.5
Nvidia GeForce RTX 2080 Super	36	137	33	100	25	61		108.8		79.6		46.4

	Ghost Recon: Breakpoint						Shadow of the Tomb Raider					
	1920x1080 Ultimate Preset		2560x1440 Ultimate Preset		3840x2160 Ultimate Preset		1920x1080 Highest Preset		2560x1440 Highest Preset		3840x2160 Highest Preset	
	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg	Min	Avg
Nvidia GeForce RTX 3070 FE	60	167	60	86	46	52	126	160	94	114	52	62
Nvidia GeForce RTX 3080 FE	60	122	60	101	53	69	159	195	110	145	70	83
Nvidia GeForce RTX 2080 Ti	60	107	61	86	46	56	129	164	94	114	54	63
Nvidia GeForce RTX 2080 Super	60	95	60	74	26	44	112	140	80	96	43	51

“What really matters is how it performs, and we’re happy to say, the 3070 does a stellar job. We found it to be only slightly behind the RTX 2080 Ti, a card that went for twice the price.”

At 220W, the TDP of the card is back to more acceptable levels and the 3070’s compact cooler doesn’t need to work anywhere near as hard to keep cool. We saw a peak temperature of 74 C. That will be a bit higher in a closed case, but we were very happy with the effective combination of cooling capability and low noise levels. Custom cards will likely be very cool and quiet.

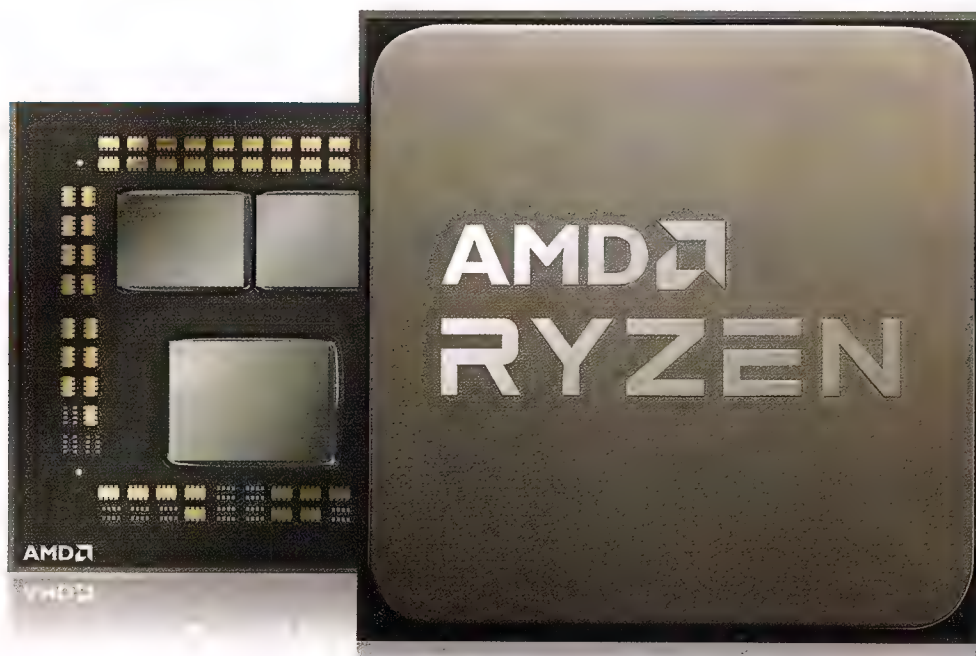
As is the case with the other Ampere cards we’ve tested, there isn’t a lot of overclocking headroom. You will gain a bit from overclocking the memory, but the card runs into its power limits quickly. Partner cards will likely

feature BIOSes that allow for less restricted power limits.

In conclusion, the 3070 goes very close to the RTX 2080 Ti at half the price. This is simply incredible. Having said that, the pricing is perhaps a little too high given that high end 3070 cards are the same price as the entry level 3080s which are a big step up in performance. Availability also remains a concern for the entire range. Then there’s the elephant in the room which is the pending release of the AMD Radeon RX 6000 series. At the time of writing we only had AMD’s performance measurements on hand. We’ll reserve judgment until

we do our own independent testing, but the competing models could end up being very strong indeed. Unless you’re particularly interested in a unique Nvidia feature such as G-Sync or DLSS in a particular game, we’d recommend holding off on your buying decision until RX 6000 cards are released. Wherever the dust settles, the consumer is the winner. RTX 3070 buyers won’t be disappointed. Don’t forget there’s the imminent release of 3060 cards to look forward to as well. It’s a fantastic time to be in the market for a new GPU.
CHRIS SZEWCZYK

The RTX 3070 competes well with the 2080 Ti at half the price, but we’d suggest waiting a little bit longer before making a decision.
★★★★☆



5800X: \$699, 5950X: \$1,249 | www.amd.com

AMD Ryzen 7 5800X & Ryzen 9 5950X

There's a new sheriff in town.

When AMD launched its first generation Ryzen processors in 2016, we applauded the massive performance uplift they brought, particularly the strong multithreaded performance. One area they tended to lag behind Intel in, though, was in single threaded performance and gaming. Though the Zen+ and Zen 2 generations closed the gap, Intel was always able to compete by refreshing its Skylake architecture with significant frequency increases.

AMD believes it has reached the inflection point where it has achieved undisputed leadership. The company claims that its CPU options win in not some, but all the relevant categories, including multi-threaded performance, single threaded and gaming performance, performance per watt and value for money. Big claims indeed! Should your next upgrade be AMD? We have the Ryzen 7 5800X and Ryzen 9

5950X on hand to answer that question.

The big changes AMD describes the Zen 3 architectural overhaul as the biggest since the first-generation Ryzen. The chiplet design and 7nm process node remain the same. Changes include improved branch prediction, reduced latency and improved caching performance. Improving latency was a key focus given this is an area where Ryzen 3000 processors lost some gaming performance. All in all, AMD claims up to a 19 percent uplift in instructions per cycle. Combine this with the increases in frequency and it's clear that 5000 series processors promise to be much faster than their predecessors.

While the I/O die remains unchanged, the core dies have undergone some fundamental changes. Six and eight core CPUs are all contained on the



SPECS AMD RYZEN 7 5800X

Socket AM4;
8core / 16thread;
3.8GHz base /
4.7GHz boost
clock; 32MB L3
cache; Supports
DDR4-3200;
105W TDP.



AMD RYZEN 9 5950X

Socket AM4;
16core / 32thread;
3.4GHz base /
4.9GHz boost
clock; 64MB L3
cache; Supports
DDR4-3200;
105W TDP.

one so called CCX whereas before they were spread across two. These cores can now access the full 32MB of cache directly which accelerates core and cache communication and reduces latency. This is key for gaming. The Infinity Fabric clock is unchanged at 1800MHz, meaning the IF clock and DDR4-3600 (or 1800MHz Double Data Rate) remains the memory sweet spot.

The 5800X is an 8-core/16 thread model with a 105W TDP. Its base clock is 3.8GHz and its boost clock is listed at 4.7GHz, though our software readings were sometimes higher than this, in fact as high as 5.0GHz. As mentioned earlier, it's got 32MB of L3 cache that all cores can access. It's priced at \$699. It can be considered a replacement for the 3800X and XT. For now there isn't a 65W option. Given the popularity of the retiring 3700X, we're a little surprised, though we may well see one later. If you wish to 'create your own' 65W processor though, you can with AMD's under-appreciated ECO mode. You'll lose a bit of performance of course but it's a game changer for some users.

The 5000 series might be killer CPUs, but only the six-core 5600X

"The company claims that its CPU options win in not some, but all the relevant categories, including multi-threaded performance, single threaded and gaming performance, performance per watt and value for money."

Best result
On test

	X264 V5.0 VIDEO ENCODING	CINEBENCH 20	CINEBENCH 20	BLENDER 2.79 BMW RENDER	7ZIP	CRU-Z	CRU-Z
	PASS 2 AVG FPS	MULTI THREAD SCORE	SINGLE THREAD SCORE	TIME (SECONDS) LOWER IS BETTER	MILLION INSTRUCTION PER SECOND	SINGLE THREAD SCORE	MULTI THREAD SCORE
AMD RYZEN 9 5950X	80.05	9,562	627	123.0	108,088	677.0	11,758
AMD RYZEN 7 5800X	51.07	5,845	609	206.2	69,871	659.0	6,698
AMD RYZEN 7 3700X	43.46	4,809	506	234.7	58,642	529.5	5,576
AMD RYZEN 9 3900X	61.34	7,205	520	154.2	83,538	548.0	8,411
INTEL CORE I9-9900K	42.70	4,918	498	217.9	50,791	546.3	5,562
INTEL CORE I9-10900K	53.70	6,357	535	167.8	61,658	562.7	7,443

	AS SSD	AS SSD	AS SSD	AS SSD	POV RAY	HANDBRAKE VIDEO ENCODING	PEAK POWER CONSUMPTION
	SEQUENTIAL READ	SEQUENTIAL WRITE	4K READ	4K WRITE	RAY TRACING - PIXELS PER SECOND	4K 10-BIT HEVC TO 1080P FPS	WATTS (SYSTEM WALL DRAW)
AMD RYZEN 9 5950X	5555.8	3982.3	84.5	209.3	8,468	76.6	216.4
AMD RYZEN 7 5800X	5581.5	3993.1	85.1	213.8	5,260	69.1	206.1
AMD RYZEN 7 3700X	5505.2	3930.6	81.5	192.8	4,298	59.3	175.4
AMD RYZEN 9 3900X	5507.7	3952.6	81.5	193.1	6,357	65.7	231.7
INTEL CORE I9-9900K	2730.8	2508.1	64.4	129.9	4,246	58.2	246.1
INTEL CORE I9-10900K	2850.2	2624.8	65.4	129.3	5,531	63.1	309.7

includes a cooler, which is a tick against them. All Ryzen 5000 CPUs are compatible with X570 and B550 motherboards. X570 boards in particular will require a BIOS update, with most, if not all X470 and B450 models adding BIOS support in early 2021.

Performance gains

The 5950X is the top model in the range with 16 cores and 32 threads. Its base clock is 3.4GHz and its boost clock is 4.9GHz. It packs in 64MB of L3 cache. This is impressive when you consider the TDP is still 105W. It's pretty safe to say that Intel doesn't have anything to compete with this CPU unless you go to ultra-expensive enterprise options. All 5000 series models are unlocked for easy overclocking, support PCIe 4.0, DDR4-3200 (officially) and other AMD technologies such as StoreMI, Precision Boost Overdrive and all can be controlled by the impressive Ryzen Master software.

Now we come to it.

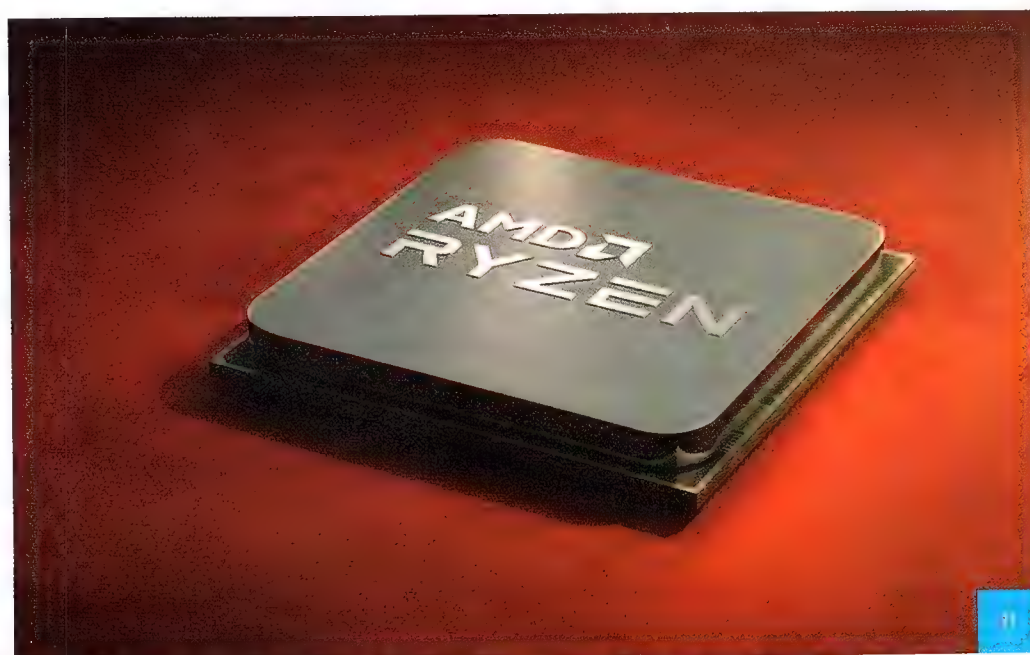
Performance. Ryzen 3000 was already competitive with Intel in multithreaded and content creation applications, but with Ryzen 5000 there is now daylight between them. Where the most impressive gains are in gaming. The 5800X can match and even exceed the 10900K, with the

5950X trending a little behind, likely due to the underutilisation of all those cores. It's definitely no slouch though. Just look at the numbers. AMD is matching or leading everywhere in performance. Well done! Power consumption levels are also impressive. In fact the 5950X system pulled 216W from the wall, less than the 231W we measured from the 12-core 3900X. This again points to a

small underutilisation. The 5800X system pulled 206W.

Overclocking is not really recommended. We were able to hit 4.6 and even 4.65GHz on all cores with our 5800X, but this is quite a way below the single-threaded boost clock. With this in mind, if you are gaming or using single threaded applications, you're better off leaving the processor at stock. The processor will boost to a higher level when

"It's pretty safe to say that Intel doesn't have anything to compete with this CPU, unless you go to ultra-expensive enterprise options."



Best result
On test

	CIVILIZATION VI			GHOST RECON: BREAKPOINT	METRO: EXODUS		MIDDLE EARTH: SHADOW OF WAR
	1080P, ULTRA, DX12, AVG FPS	1080P, ULTRA, DX12, MIN FPS	1080P, ULTRA, DX12, AI TURN TIME	1080P, LOW, AVG FPS	1080P, ULTRA, DX12, AVG FPS	1080P, ULTRA, DX12, MIN FPS	1080P, LOWEST PRESET, AVG FPS
AMD RYZEN 5 5950X	206	146	6.97	168	100.8	51.8	317
AMD RYZEN 7 5800X	213	153	6.65	178	102.8	56.2	312
AMD RYZEN 7 3700X	198	153	6.89	171	99.7	48.6	228
AMD RYZEN 9 3900X	211	150	6.98	173	98.3	48.9	231
INTEL CORE I9-9900K	207	149	7.12	177	99.0	54.8	259

	FAR CRY NEW DAWN		3DMARK TIMESPY		3DMARK TIMESPY EXTREME	
	4K ULTRA PRESET AVG FPS	4K ULTRA PRESET MIN FPS	OVERALL SCORE	CPU SCORE	OVERALL SCORE	CPU SCORE
AMD RYZEN 5 5950X	77	65	14,166	13,318	6,847	8,109
AMD RYZEN 7 5800X	77	66	13,824	11,726	6,466	5,510
AMD RYZEN 7 3700X	76	64	13,487	9,943	6,325	4,537
AMD RYZEN 9 3900X	76	65	13,948	12,232	6,681	6,833
INTEL CORE I9-9900K	77	65	13,539	10,376	6,635	4,920
INTEL CORE I9-10900K	77	65	13,836	12,300	6,565	6,205

conditions allow without the heat and power consumption penalty associated with a heavy all core overclock. It's a similar story with the 5950X.

Returning to our original question – should an AMD 5000 series processor be your next upgrade? The answer is yes. Gamers using current Intel Z490 systems will see more of a side grade, though only in terms of gaming performance. Anything

related to content creation, power consumption and cooling requirements see AMD take a bigger lead than it had already. With a hot summer coming, cooling is key and AMD has a huge lead there. Upgrading from early Ryzen or pre-Skylake systems will see massive performance improvements as well as better feature support.

The 5800X has killed Intel's gaming leadership narrative. It

“The 5800X has killed Intel's gaming leadership narrative. It doesn't make gaming on Intel irrelevant by any stretch, but if you add the other strengths including energy efficiency, multi-threaded performance and platform feature advantage then it's a clear winner.”

Pic: AMD

doesn't make gaming on Intel irrelevant by any stretch, but if you add the other strengths including energy efficiency, multi-threaded performance and platform feature advantage then it's a clear winner. The 5950X is also a stellar CPU but for some different reasons. A 16-core CPU isn't yet ideal for gaming as we see some games struggle to optimally utilise the cores or the chiplet topology. It should be considered the king of multi-threading and content creation. Intel has nothing at the consumer level to compete with it at all.

AMD knows it's got a winner on its hands so pricing has trended upwards, plus you'll need to buy a cooler. But if you're upgrading a compatible AM4 system, this is a moot point. It's really only the price creep that causes Ryzen 5000 to lose a smidgen of its shine. The king sets the rules though, and for now, the king is AMD. Oh, to be a fly on the wall at Intel headquarters right now. CHRIS SZEWCZYK



AMD's Ryzen 5000 series takes the outright performance crown. Full stop.

5800X: ★★★★★

5950X: ★★★★★



From \$2,399 | dell.com

Dell XPS 13

Is this year's XPS extra special? Dell's new integrated GPU puts gaming potential on the ultraportable.

Dell's XPS range has long been one of the best available professional ultrabooks, but the late 2020 XPS 13 (9310) has upped the ante with a new processor and a considerable price cut that puts it, once again, at the top of the game.

The XPS range pioneered the race for the best screen to body ratio with its ultra slim infinity bezels, and it's improved on them again this year by another eight percent over the earlier 2020 XPS 13. This 16 by 10, 13.4-inch display can be configured with either a 500 nit Full HD+ or a 4K HDR screen with a DCI P3 colour gamut. While the 4K model has touchscreen capabilities you can opt for a non-touch variation of the 1080p screen, but all three offer Dolby Vision for HDR media playback.

This device is powered by a new range of 11th Generation Intel processors that see pretty normal generational boosts in performance of between five and 20 percent

across various work benchmarks, but they also come with a new range of integrated GPUs that have a massive impact on graphical performance. On demanding tasks the Intel Iris Xe Graphics on the XPS 13 (9310) doubled the performance of the Intel Iris Plus Graphics that we saw on the previous generation. This is enough of a performance bump to put light 1080p gaming within reach, offering playable frame rates of around 30fps on current titles like *The Division 2*, *Metro: Exodus* and *Civilization VI* when running Low graphical settings at 1080p resolutions. The same settings get closer to 60fps averages on *Total War Saga: Troy* and *F1 2020* and you'll get much faster frame rates on less demanding titles like *Fortnite* or *Rocket League*.

The late 2020 XPS 13 (9310) comes with either an Intel Core i5-1135G7 or a Core i7-1165G7 CPU locally and each starts with

SPECS

Windows 10 Home
64-bit, 13.4-inch
500nits IPS
display @ 3840 x
2400 pixel
resolution; Intel
Core i7-1165G7
CPU; Intel Iris Xe
Graphics; 16GB
RAM; Killer Wi-Fi 6
AX1650; 48Wh
battery (8h51min
in PCMark 10
Work battery);
29.6x19.9x1.5cm;
1.27kg.

respective RRP's of \$2,399 and \$2,899 for the non touch FullHD models. If you want the touch panel it'll cost an extra \$100 while the 4K screen will add \$500 to the bill. While the i5 variant comes with 8GB of RAM, the i7 model comes with either 16GB or 32GB and can expand the included PCIe SSD storage from 512 GB to 1TB.

The new XPS 13 also sees an improvement in processor efficiency that generates a 20 percent increase in 1080p movie playback lifespan. The new seven hour total achieved by the 48Wh battery isn't quite what you need for a full day of productivity, but it is more than enough to get you through most of a daily workload.

Dell's still using fibreglass for the palm rest surround to insulate your hands from the internals and it's available in either black or white colourings with a honed silver or frost coloured metal chassis to match. It's a worthy consideration since the late 2020 XPS 13 runs hot, with CPU cores frequently spiking to 100 degrees.

Considering that it's also got a decent set of speakers, a comfortable keyboard, a responsive trackpad and sufficient webcam capabilities, the late 2020 XPS 13 ticks every box it needs to be a great ultrabook.

JOEL BURGESS

Solid integrated graphics improvements and a local price cut put the XPS 13 back on top of the pile of professional ultrabooks.

★★★★★

■ Best result
■ On test

	Dell XPS 13 late 2020 (9310)	Dell XPS 13 early 2020 (9300)
PCMark 10 - Overall (score)	4,564	4,340
Cinebench R20 - CPU (multi-threaded)	2,851	1,664
Geekbench 5 - Multi-core (score)	5,429	DNT
3DMark Fire Strike (score)	2,498	2,528
Battery life - 1080p video playback (h:min)	07:00	05:50
Peak CPU temperature (°C)	100	100
CrystalDiskMark Read (MB/s)	3,165.8	3,104.8
CrystalDiskMark Write (MB/s)	3,069.1	2,672.6



\$2,162 | online.acer.com.au

Acer Spin 5

Acer's sleek convertible has a stylish stylus, but is this Spin-ster the perfect match for your lifestyle?

The Spin 5 is Acer's flagship consumer 2-in-1 and although you end up paying a little more for it than the similarly specced Swift 5 laptop, there's a few additional handy features for anyone looking to use this convertible as a tablet. Acer has collaborated with specialist stylus and digital drawing pad creators, Wacom, to help give the Acer Active Stylus a smooth and natural feel when writing and drawing. Using it with Windows 10's write to type functionality in the search bar the stylus felt comfortable and responsive; it also offered a slightly neater flow than what your hand actually draws in applications like Paint, so you should be able to get it

working well with your drawing app of choice.

The 2020 Spin 5 comes in other configurations internationally but in Australia it uses an Intel Core i5-1035G4 CPU and 8GB of RAM, which will be more than enough for most people's working needs. It is about 20% less powerful than the devices running i7 processors with 16GB of RAM here, so you'd probably steer clear if you plan to do a lot of photo editing or you're running intense design software. But it's got more than enough for web browsing, office applications, simple drawing apps and a bit of light gaming.

Battery life was decent with the device lasting eight hours

SPECS

Windows 10 Home
64 bit; 13.5-inch
IPS display at
2256x1504 pixel
resolution; Intel
Core i5-1035G4;
8GB RAM; Intel
Iris Plus Graphics;
256GB NVMe SSD;
30x23.5x15cm;
1.2kg.

and 15 minutes in 1080p movie playback and using the PCMark Battery Benchmark nets 10 hours and 35 minutes, so you'll be fine to get a full day's working battery for light tasks even at full brightness.

Acer followed Microsoft's Surface devices with a 3:2 format display at a 2256 by 1504 pixel resolution. This 13.5 inch screen has a thick bottom bezel, but the device still looks premium, with an overall 80% screen to body ratio.

The trackpad and keyboard both feel good to swipe/type on respectively and there's no shortage of connectivity options with a HDMI out, 2 x USB Type-C and a microSD Card reader (alongside a couple of regular USB Type-A sockets and a 3.5mm audio jack). The hinge design also struck a good balance between offering support at all angles without being unmovable.

The 256GB storage is a little small to be ideal and it's also not the fastest we've encountered, but it is still connected via a PCIe lane so it'll be between two and four times as fast as any SATA SSDs.

The 2-in-1 also features an Intel Wi-Fi 6 network adapter, so you won't have to worry about any lag when you're connected to a local area network.

JOEL BURGESS

"Acer has collaborated with specialist stylus and digital drawing pad creators, Wacom, to help give the Acer Active Stylus a smooth and natural feel when writing and drawing."

■ Best result
■ On test

	Acer Spin 5	Acer Swift 5
PCMark 10 - Overall (score)	3,404	4,334
Cinebench R20 - CPU (multi-threaded)	487	1,337
HWBot x265 - 1080p (fps)	19.015	17.705
3DMark Fire Strike (score)	1,928	2,358
Battery life - 1080p video playback (h:min)	08:15	07:32
Peak CPU temperature (°C)	85	94
CrystalDiskMark Read (MB/s)	1,944.3	1,739.2
CrystalDiskMark Write (MB/s)	1,010.6	1,452.8

A neat 2-in-1 with a lightweight stylus that is great for basic office tasks.

★★★★☆



From \$4,999 | store.hp.com

HP Envy 15

Is HP's new pro laptop capable of inspiring the envy of others... or just stirring it up amongst entrenched customers?

HP has a few flagship laptops that sit in the premium ultrabook space, but while most tend to skew towards a lightweight ultrabook style, the new Envy 15 is designed to be more of a powerful premium laptop. The range opens with a strong Intel Core i7/16GB RAM/Nvidia GTX 1660Ti configuration, which goes for \$3,599. Add another \$900 to this lofty price and you can replace the 15.6-inch Full HD 1080p display with a 400 nit 4K HDR monitor and dial up the GPU to an RTX 2060 (Max-Q). Both these units come with a 512GB NVMe SSD, which offers super fast 2,751/1,496MB per second respective read and write speeds. In order to fill out that premium SSD to 1TB you'll have to fork out for the top of the line \$4,999 Envy 15, the device we've tested here.

For such a high end device the keyboard, trackpad and speaker surround is pretty bland, looking like a squarish ripoff of a Blade 15

(which is already a 15-inch MacBook Pro rip-off). This pedestrian looking chassis is only available in what we imagine must be called 'Dull Grey' and while there is at least some dimension to the body, it still feels like if it were any thicker it'd be indistinguishable from a box.

Fortunately looks are only so consequential and there's the odd redeeming feature in the design like the recessed, trackpad-adjacent fingerprint reader. Despite their appearance the trackpad is soft and responsive, the keyboard comfortable to type on and the top firing Bang and Olufsen speakers are loud enough for personal use. If you do need to do any professional colour work, the 4K versions have screens that are capable of reproducing the DCI-P3 colour gamut with a Delta E of less than two and the device does include a couple of Thunderbolt ports so you can hook it up to multiple high

SPECS

Windows 10 Home; 15.6-inch AMOLED display @ 3,480x2,160 pixel resolution; Intel Core i7-10750H CPU; Nvidia GeForce RTX 2060 (Max-Q); 16GB RAM; 1TB NVMe SSD; 78Wh battery (3hour 12min 1080p movie playback); 35.8 x 26.4 x 18.4cm; 2.14kg.

resolution screens if you need to work on a larger scale. The 400-nit AMOLED display looks vibrant and offers a much bigger contrast ratio when compared with traditional LED screens.

The Envy 15 is running one of the best performing laptop processors available, the hexa-core i7-10750H CPU, but it's a little late to the party since many competitors launched devices with these chips in the middle of 2020 – Dell even has an 11th gen Intel CPU in its XPS 13. Still, this processor is one of the best value high performance CPUs and it's more than capable of churning through demanding video rendering and general processing workloads. Add the RTX 2060 GPU, which can run Ultra 1080p ray traced *Metro: Exodus* at 35fps and you have more than enough processing power for tackling demanding graphical workloads on the go.

There is one last thing you should be aware of... the battery is abysmal. This powerhouse can only keep its demanding processors running for one hour and 49 minutes in PCMark 10's Work Battery benchmark or three hours and 12 minutes in media playback. You might even want to fork out for a couple of chargers if you're planning on moving it around a lot.

JOEL BURGESS

A powerful work laptop that ticks all the boxes but seems a little square for the bold price tag.

★★★★☆

■ Best result
■ On test

	HP Envy 15-sp0067tx	Lenovo Legion i5
PCMark 10 - Overall (Score)	4,319	4,778
HWBot x265 - 1080p	22.831	35.695
Cinebench R20 - multi-threaded CPU	2,857	3,091
1080p movie playback time (Hours:minutes)	03:12	02:42
3DMark Time Spy (score)	5,282	4,075
Tom Clancy's: The Division 2 - Ultra 1080p (fps Av.)	37.3	62.3
CrystalDiskMark Read/Write (MB/s)	3,217	3,502
CrystalDiskMark Read/Write (MB/s)	3,067	2,979



\$1,449 | msi.com

MSI Pro 24X Series

MSI makes a move on professional all-in-ones, but is the Pro 24X Series a one hit wonder, or more of a one star work PC?

While the sharp monitor stand accompanying MSI's new Pro 24X Series might give off the impression this all-in-one is ready to cut through some demanding games, there's nothing but business under the hood of MSI's latest. If you weren't convinced by the name, a quick glance at the spec sheet is enough to make it clear that this PC has been designed with pragmatism in mind. The Pro 24X Series is fitted with a totally standard 23.8-inch 1080p 60Hz IPS panel run by a just-powerful-enough integrated 10th generation Intel GPU.

You control this 'space saving' setup with the included chiclet keyboard that's reminiscent of something you would have typed on while checking emails in an internet cafe somewhere in Asia in the early 2000s... only it's perhaps a little more springy and you can't unlearn your dependency on the now ubiquitous backlight.

The Pro 24X can be configured with a 10th generation Intel Core i3, i5 or i7 CPU, depending on how demanding your day-to-day work will be, but seeing as the devices start at around the \$1,000 mark for the entry level processors and range to \$1,450 for an i7 configuration we really wouldn't recommend going for anything less than the i5-10210U CPU – unless you're really only buying it to check emails each Wednesday.

The Pro 24X Series is one of those devices sold in exclusive configurations through different outlets, so be sure to take note of the model number if you are hoping to buy the exact model you read about. We tested the Pro 24X Series 10M-081AU, which comes with the Core i7-10510U CPU, 16GB of RAM, a 512GB PCIe SSD from WD and an Intel Wi-Fi 6 AX201 networking chip and retails for around \$1,449 (or \$1,899 if you want Windows 10 Pro rather

SPECS

Windows 10 Pro
64-bit; 23.8-inch
IPS display @
1920x1080 pixel
resolution; Intel
Core i7-10510U
CPU; Intel UHD
Graphics for 10th
Gen; 16GB RAM;
512GB PCIe SSD;
Intel Wi-Fi 6
AX201;
53.8x40x17cm;
4.44kg.

than Home).

As the top of the line unit, it's unsurprising that it'll be able to dig you out of the vast majority of spreadsheet, browser and light editing workloads, but even the Core i5 model should be sufficient for the vast majority of modern workflows. While it wasn't the fastest we've tested, the 512GB SSD was three and more than ten times faster, respectively, than SATA or older HDD-based desktop hard drives, which you really notice in overall boot and loading times. The Wi-Fi 6 and Gigabit Ethernet ports also offer the latest specifications and will help keep the devices responsive for years to come.

With two networking ports, six USB sockets, an HDMI output and 3.5mm audio jack there's enough interface options to keep most modern employees satisfied and the hard drive slot has been built on the edge of the chassis so you can upgrade if you ever need to in the future.

You can definitely find better priced devices around, but the Pro 24X Series is quiet, compact and competent, so we can't see anyone really regretting this purchase.

JOEL BURGESS

■ Best result
■ On test

	MSI Pro 24X Series	Dell OptiPlex 7070 Ultra
PCMark 10 - Overall (score)	4,235	3,832
Cinebench R20 - CPU (multi-threaded)	1,240	1,445
HWBot x265 - 1080p (fps)	17.757	19.49
Geekbench 5 - Open CL (fps)	5,668	DNT
3DMark - Time Spy (Score)	430	403
Peak CPU temperature (°C)	100	100
CrystalDiskMark Read (MB/s)	1,739.1	2,281
CrystalDiskMark Write (MB/s)	1,456.1	2,281

A sleek all-in-one work device that ticks all the essential boxes and ends up at a fair price.

★★★★☆



\$949 | msi.com

MSI Cubi

With so many affordable laptops around, is MSI's Cubi a bit like a square PC trying to fit a round hole?

If you've got an old monitor, keyboard, and mouse lying around and you just want a basic PC that's capable of web browsing and light office tasks, then there's plenty of suitors, but not many are as affordable as you might think. The absolute best value PCs will be built in the same chassis as ones that are far more capable, which means they contain a heap of dead space that'll end up occupying your desk.

All-in-one's are still a viable option, but if you have screen and interface options already then the new display is an unnecessary cost. Buying a laptop and running a HDMI, DisplayPort or USB Type-C/Thunderbolt to a monitor is still the best option, price wise at least. This is especially true if you'd get any use out of a PC that you can use on-the-go, but if you're certain you'll never need a computer outside the home and would really prefer a non-laptop-

shaped PC then there are at least some options in the NUC space that'll scratch your very particular itch.

MSI's Cubi is one such box; the 12.4cm square is just 5cm tall and comes with a full suite of connectivity options from USB Type-C to a DisplayPort, or Ethernet to 3.5mm headphone and mic jacks. While not all the available configurations come with Windows 10 Home pre-installed, or even a storage solution for that matter, the Cubi we tested ran on an Intel Core i5-10210U CPU, 8GB of RAM and a 512GB m.2 PCIe SSD. This particular unit retails for around \$949 but you can get MSI Cubis for as little as \$529 if you bring your own RAM, SSD and OS.

The i5-10210U CPU has more than enough power to push through most modern work tasks, and while you won't want to tackle any Photoshop work with

SPECS

Windows 10 Home
64-bit; Intel Core
i5-10210U CPU;
8GB RAM; Intel
UHD Graphics;
512GB m.2 SSD;
Intel Wireless AC
9462;
12.4x12.4x5.4cm;
1.4kg.

just 8GB of RAM, you should be OK to do some lighter photo editing with less demanding image editing apps if need be.

The onboard Ethernet port means we can overlook the fact that this unit missed out on Wi-Fi 6, but it will give the device a much shorter shelf life for anyone planning on using it with a cord-free internet connection.

If you do get a unit with an included m.2 SSD you'll be looking at respective read and write speeds of 2800MB/s and 2500MB/s, which is a big step up from a hard disk drive or SATA 3 connected SSD. It makes this lightweight device feel responsive and powerful.

The integrated Intel UHD Graphics is capable of a maximum output of a little more than 4K at 60Hz, so you won't have trouble connecting multiple monitors at up to 1440p using the HDMI and DisplayPort connections. The Cubi also comes with VESA mounting screws so you can attach it to the back of one of your screens to keep it out of the way.

To many the MSI Cubi will be a bit of a hard sell since you can get more powerful laptops for less, but if you're after a barebones NUC, this one ticks all the boxes. JOEL BURGESS

A decent compact PC for lightweight workloads that will appeal to a niche market.

★★★★☆

■ Best result
■ On test

	MSI Cubi	Dell OptiPlex 7070 Ultra
PCMark 10 - Overall (Score)	3,443	3,832
Cinebench R20 - CPU (multi-threaded)	1,146	1,445
HWBot x265 - 1080p (fps)	16.163	19.49
Geekbench 5 - Open CL (score)	4,798	DNT
3DMark - Time Spy (Score)	380	403
Peak CPU temperature (°C)	75	100
CrystalDiskMark Read/Write (MB/s)	2,876.6	2,281
CrystalDiskMark Read/Write (MB/s)	2,518.4	1,263



\$379 | www.benq.com

BenQ Mobiuz EX2510

On paper, it packs a punch at the price. But, is it too good to be true?

The world of gaming monitors is commoditised to the point where most models offer something different to everything else on the market. In the case of BenQ's Mobiuz EX2510 its feature set places it somewhere around the top-end of the budget market and the bottom end of the mid-range market. So, who, if anyone, should buy it?

The headline features include a 24.5-inch, Full HD, 144Hz gaming monitor with HDR, decent built-in speakers and good ergonomics. It uses an IPS panel and subsequently offers good colour performance and viewing angles but its true black reproduction can't rival the best monitors or TVs (not that you'd want that when competitive gaming). It makes use of BenQ's innovative, software-based 'HDRi' emulation technology, which optimises contrast and colour saturation based upon content (or an ambient light sensor). In practice it worked rather well: a button in the lower right-hand corner switches between Game, Cinema and (normal) HDR modes and they add more vibrancy to a regular screen. It's

far removed from the 1,000-nit, rear-lit premium rivals which reproduce lighting that looks like it's shining out of the screen, but we were generally impressed with the bright, 400-nit panel's ability to display bright colours on a dark background. That said, highlights in games could get washed out – it's better at revealing enemies in shadows than in the sky.

The 144Hz refresh rate kept all objects moving smoothly and sharply. That's because pixels have a low, 1ms response time (using the Motion Picture Response Time measure) and are capable of 2ms grey-to grey transitions – very fast for an IPS panel. Various settings allow you to tinker with the results' success dependent on personal preference. Nonetheless, it's capable of producing smooth and vibrant gaming and a crisp and usable desktop for work.

The stand is solid and looks classy while the screen is surrounded by an impressively thin bezel. It's matte-finished rather than glossy, but while 'black mirror' reflections are cut out, it can still reflect significant ambient glare in bright rooms.

Two 2.5W speakers are built-in and provide impressive day-to-

SPECS
24.5-inch, matte,
1,080 x 1,920,
flat-screen,
144Hz LCD with
IPS panel, 1ms
MPRT & 2ms G2G
response time,
400 nit
brightness,
1000:1 contrast,
FreeSync, HDRi, 2
x DisplayPort 1.2,
2 x HDMI 2.0,
3.5mm audio jack,
2 x 2.5W
speakers. Tilt
-5o/+20o, Swivel
20o/20o, Height
adjustment
130mm. 521 x
558 x 217 mm,
7.7kg.

day audio. However, when things get loud, the lack of bass becomes apparent, especially when playing music or listening to booming gaming effects.

The stand pivots, rises/lowers and swivels to a generous degree but rotation is negligible. Connectivity includes a headphone jack, two HDMI 2.0 ports and a DisplayPort 1.2.

The OSD is intuitively controlled by a mini joystick at the rear. This provides responsive changes (and previews) to setting adjustments.

Under general usage we really liked it. However, we did notice a potential glitch in that, when Windows' frequency and a game's frequency were mismatched, the screen repeatedly turned off for a few seconds. However, so long as everything ran at 144Hz, there were no issues.

At \$379, the Mobiuz represents great value. The only weakness is a loss of detail in bright areas but, beyond that, it ticks every box you'd want from a reasonably priced gaming monitor..

NICK ROSS

A great value option that covers all the basics.

★★★★★



\$479 (38mm), \$499 (42mm) | withings.com

Withings ScanWatch

The first to market smartwatch that can record an ECG.

Every smartwatch and fitness band out there will tell you your heart rate, which they do via optical sensors that look at blood vessels to measure variation in blood flow. Fidelity is generally low, but absolutely good enough for taking a quick check or monitoring your heart rate during exercise. But, only the Withings ScanWatch can do a medical-grade ECG (electrocardiogram), measuring with astonishing accuracy the electrical impulses in your heart that are used to get a super accurate reading.

Just launched in Australia, it beats the Apple Watch (and many others) with this feature, and, is approved by the Australian government's Therapeutic Goods Administration as a medical device. This makes it a game-changing product and – for many – a potentially life saving bit of tech.

Half a million Aussies have an irregular heartbeat, and many won't know they do. The condition, known as Afib (atrial fibrillation), can dramatically increase the risk of stroke, and until now you needed a visit to your GP or a cardio specialist for

it to be detected and monitored.

The ScanWatch uses three electrodes to do an ECG measurement – one on the front and two on the back of the watch. To take a reading you place your non-watch-wearing hand over the top of the watch, being sure to touch the metal bezel, and hold it there for the 30 seconds it takes. This creates an electrical circuit and allows an ECG reading of your heart's electrical activity. Your ECG displays on your phone via the excellent Withings Health Mate app in real time, is stored for future reference, and can be shared as a PDF or jpeg.

Not all people with Afib have it all the time, so the Scanwatch can be set to look for signs of Afib every 10 minutes via its optical cameras, and alert the user if it's detected – at which point it will recommend taking an ECG reading. That would also be the time you stop what you're doing, relax and breath deeply and think about seeing your doctor.

It's other notable health feature is an accurate blood oxygen saturation sensor, which works via a dedicated sensor that emits a light wave at your wrist, which then reflects off visible blood vessels and measures oxygen

saturation based on the colour of the blood. The same sensor can also detect sleep apnea – something many people will have no idea they might have.

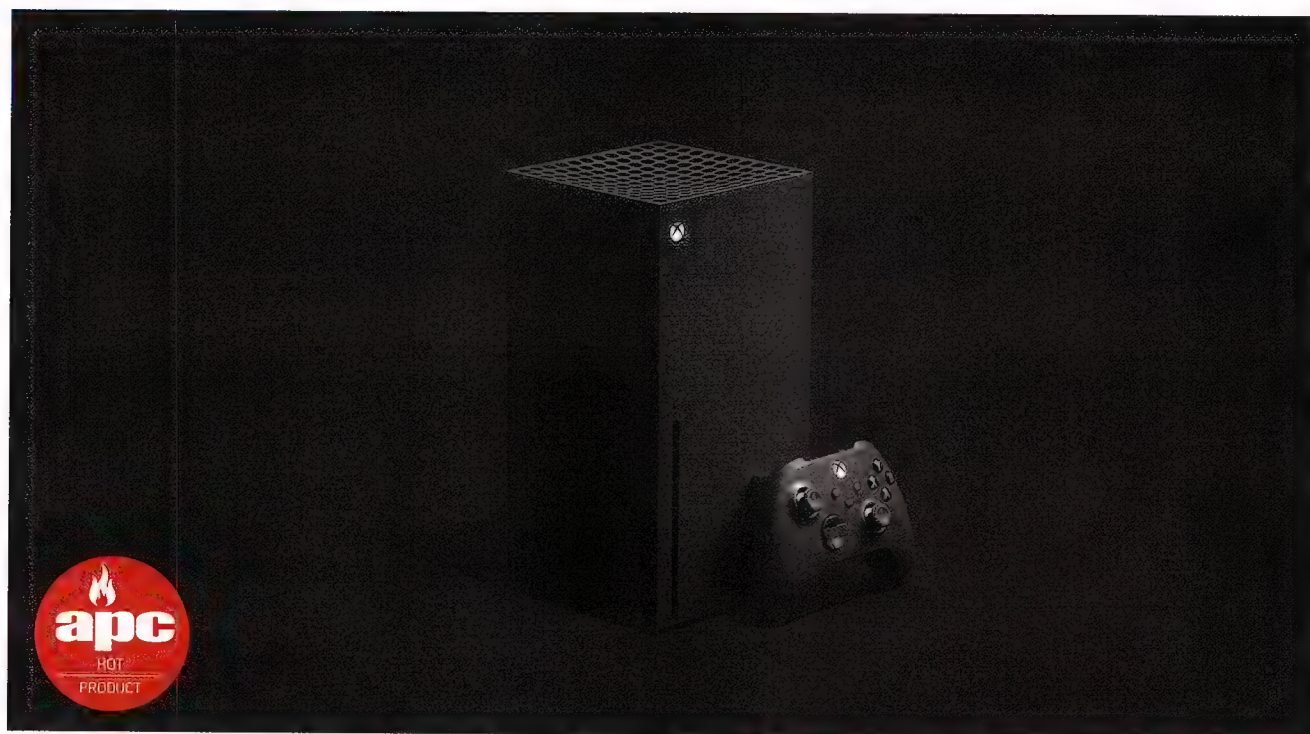
The ScanWatch also does pretty much every single thing you'd expect of a health-oriented smartwatch, from setting and achieving activity goals, to sleep monitoring. It's waterproof to 50m, has up to 30 days of battery life and is light and comfortable to wear. It could easily pass as a dress watch. It's actually quite beautiful.

At the price it's a steal. I was unexpectedly diagnosed with a pretty bad case of Afib just a week before the ScanWatch was announced for Australia. It was as surprising as it was scary, and I face a long road ahead of treatment. The ScanWatch is now staying on my wrist 24/7, monitoring my heart and helping me live a longer and healthier life.

BEN MANSILL

A government-certified, potentially life-saving medical device, with bonus James Bond looks and style.

★★★★★



\$749 | microsoft.com

Xbox Series X

Microsoft's new console makes games more accessible than ever.

Following its poorly executed 2013 launch, the Xbox One evolved into a decent console throughout its seven year lifespan: its iterative successor, the Xbox One X, was (and still is) the most powerful eighth generation console. Under the direction of Xbox head Phil Spencer, features like backwards compatibility and the Xbox Game Pass subscription service helped bolster Microsoft's console strategy going forward.

The newly released Xbox Series X is the crystallisation of those developments: it's a powerful modern console with a massive library right out of the gate, and a subscription service that makes games accessible for people unwilling or unable to fork out \$100 for a new blockbuster title.

The funny thing is, Xbox Series X's hardware chops don't have a lot to show for at launch. With the absence of a heavy-

duty first-party launch title like, for example, Sony's *Demon's Souls* and *Spider-Man: Miles Morales*, there's a sense of quiet about the event (*Halo: Infinite* was meant to be the jewel in the crown, but it was delayed into 2021). There is not a single game on Xbox Series X that you can't, albeit in a less impressive manner, also play on a 2013 Xbox One. Launching the console for the first time can be dispiritingly familiar: the UI is the same as the Xbox One. The strongest first impression comes via the NVMe SSD drive, which makes booting the console and handling the UI a breeze.

Microsoft has definitely taken a leaf out of the smartphone playbook: it doesn't necessarily want you to feel dazzled by a shiny new user experience, it's just bringing more power to the table. Console launches have always been a clearing of the decks, but with the ascendance of live service games like

SPECS
 CPU: 8-cores @ 3.8 GHz (3.6 GHz w/ SMT) custom Zen 2 CPU;
 GPU: 12 TFLOPS, 52 CUs @ 1.825 GHz custom RDNA 2 GPU;
 memory: 16 GB GDDR6 w/ 320b bus;
 memory bandwidth: 10GB
 internal storage: 1TB custom NVMe SSD;
 I/O throughput: 2.4 GB/s (Raw); 4.8 GB/s expandable storage: 1TB expansion card.

Destiny 2, and ever-evolving free-to-play games like *Fortnite*, that routine no longer makes sense. User habits aren't going to pivot away from these hobby games just because Microsoft or Sony says it's time, and the Xbox Series X is very much a product of this realisation. Platforms no longer take centre place because games themselves are the platforms, now. Hence Microsoft's insistence on cross-platform play, hence its courting of Nintendo, and hence its disposing of the concept of first-party console exclusives in favour of shipping on PC too.

The nitty gritty

The monolithic tower (it's hardly a "box") houses a custom AMD RDNA 2 GPU boasting 12 teraflops speed, with a custom AMD Zen 2, eight-core CPU running at 3.8GHz. There's 16GB of RAM inside, and a 1TB NVMe SSD. These are custom components, but for reference, this means the GPU is roughly the equivalent of an RTX 2080, while the CPU is close to a Ryzen 7 3700X.

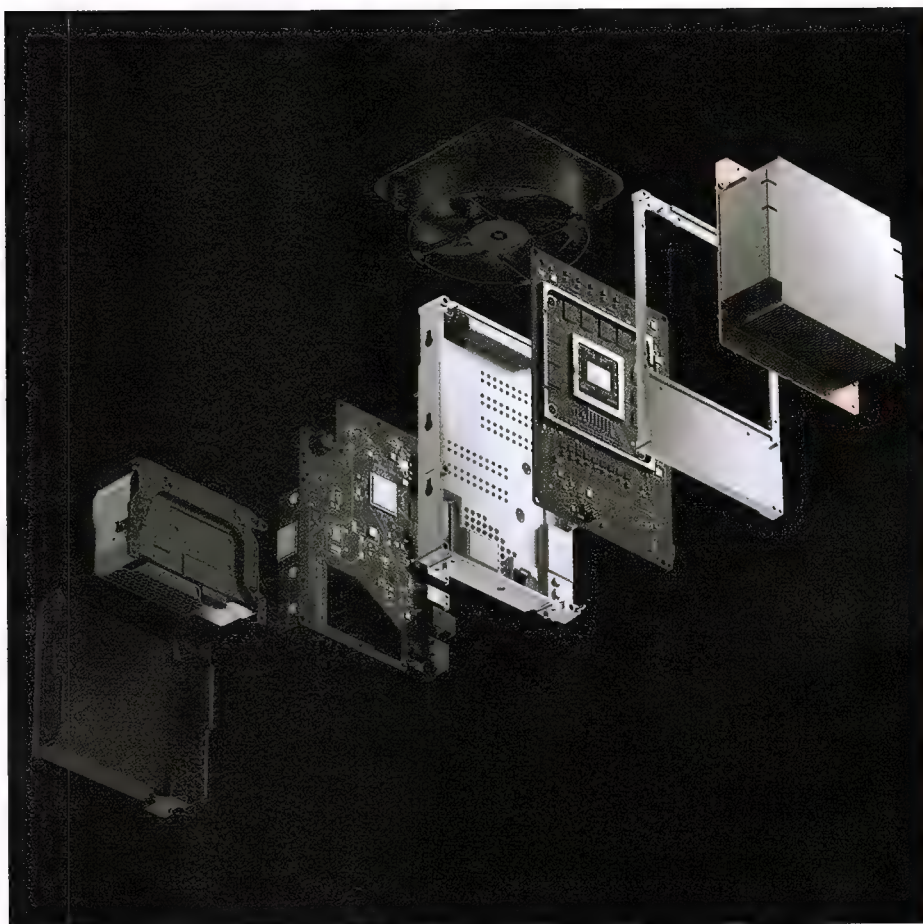
*"With the absence of a heavy-duty first-party launch title like, for example, Sony's *Demon's Souls* and *Spider-Man: Miles Morales*, there's a sense of quiet about the event."*

In other words, this is a very powerful console, but if you're a big spender you'll be able to build a more powerful PC – that's not unexpected, that was the norm for eighth generation consoles, too. But consoles aren't PCs, and the Xbox Series X has a lot going for it in other areas, to the extent that the idea of going back to an Xbox One (or PS4) is tiresome. Xbox's Quick Resume is the most remarkable quality-of-life improvement: if you're in the habit of playing more than one game at a time, the Xbox Series X keeps your progress cached. For example: if you're mid-mission in *Watch Dogs Legion*, but want to jump back into a race in *Forza Horizon 4*, you can jump back into that race without closing *Watch Dogs Legion* and rebooting *Forza*. This channel-hopping feature works for up to five games.

While loading screens haven't been eliminated entirely, they're drastically improved. One of the worst offenders for interminable loading times on Xbox One was *Forza Horizon 4*, which takes just under two minutes from selecting the game to getting behind the wheel. On Xbox Series X, that's carved to a minute. Another example: *Monster Hunter World* takes just above 1:40 to get into the game on Xbox One X, whereas on the new console it's just under thirty seconds.

That said, at release one of the next generation's biggest sales pitches hasn't proven too impressive. It's hardly Microsoft's fault, but the implementation of realtime shadows and reflections in *Watch Dogs Legion* and *Dirt 5* are hardly going to impress anyone but the most attentive. Sadly, in the case of *Legion*, there's no option to toggle these features off in favour of a smoother 60 frames-per-second mode. It'll probably take an impressive first-party implementation – similar to what Sony has with *Spider-Man: Miles Morales* for PS5 – for the benefits here to show themselves.

Xbox Series X also improves old Xbox One and Xbox 360 games – in some cases, radically. The loading speed of the SSD works across the board, no matter how deep you dive



"It's no exaggeration that within hours of testing the Xbox Series X, the prospect of returning to a HDD-based console was frightening."

into the Xbox back-catalogue, and all games that we've tested with uncapped framerates have been able to hit 60fps, ranging *Rise of the Tomb Raider* through to *Grounded*.

This is absolutely fundamental to Microsoft's Xbox positioning, more so than having even one perfectly exclusive title. This box will not only play all your Xbox One games (and most of your 360 games) but it will make them better in several ways. It's no exaggeration that within hours of testing the Xbox Series X, the

prospect of returning to a HDD-based console was frightening.

The next generation
Given the value proposition, it's hard to see the Xbox Series X failing, though generation cycles can throw up curveballs: no one expected VR and iterative console roll-outs in the eighth generation. But on Day One, it's very easy to see the promise of the Xbox Series X. Gaming has never been this accessible and convenient, and if you're already a PC gamer and bleeding edge tech (or VR) isn't your bag, the flexibility here, not to mention Microsoft's pledge to make its first-party titles PC-friendly, is optimum.
SHAUN PRESCOTT



We've already upgraded ours

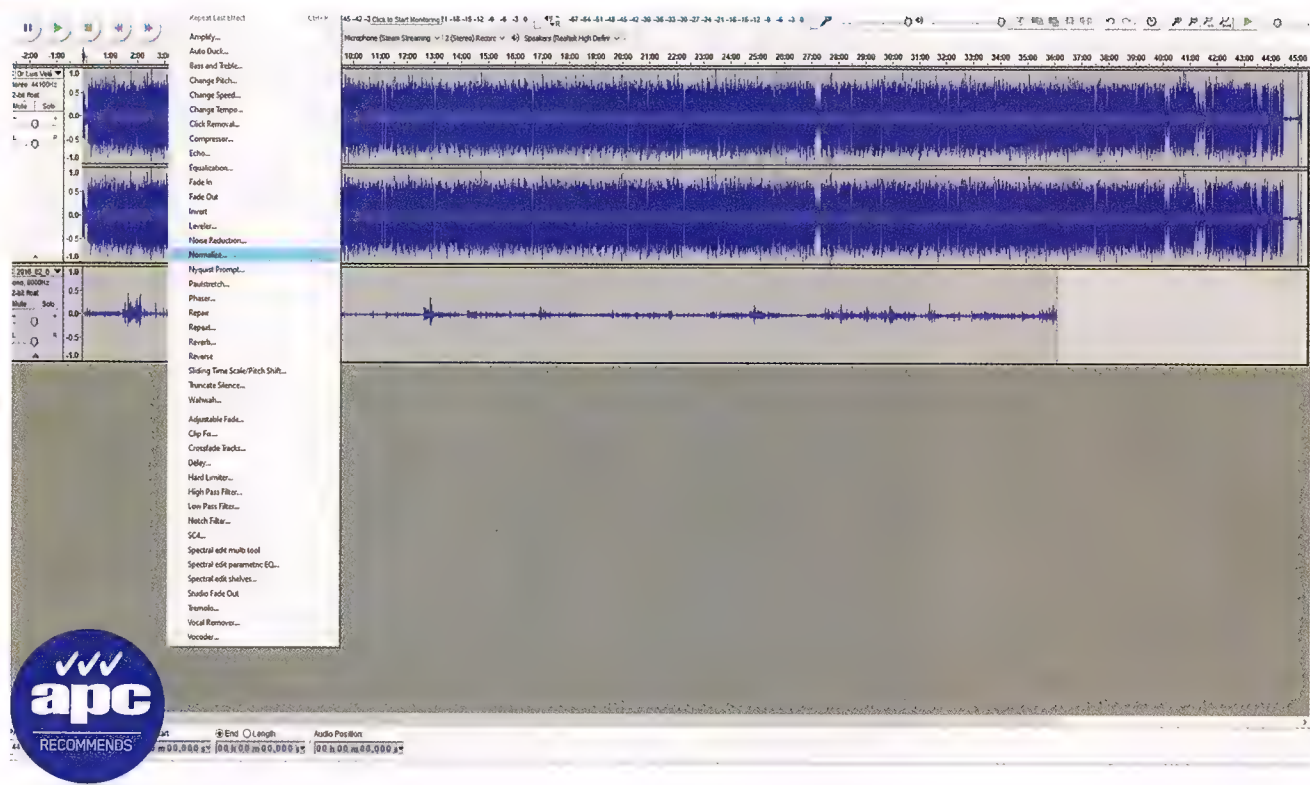
For the purposes of our review Seagate sent us an Xbox X Expansion Card, which slots right into the back of the Series X. It has a 1TB capacity, and according to all of our tests it can load games just as quickly as the console's internal drive. It is certainly pricey, with a street price of AU\$359. But at the moment, it's your only option, and there's no claiming it doesn't get the job done.

A new dawn for a new generation with impressive hardware capabilities, plus the benefits for older games is just wonderful.

★★★★★

SOFTWARE

APPS FOR ALL YOUR PLATFORMS



WINDOWS

Audacity | Free | www.audacityteam.org Adobe Audition | \$29.99 per month | www.adobe.com/au

Audacity vs Audition

Battle of the digital audio workshops.

Podcasts, eh? We've heard of them. If you're going to start recording your thoughts for posterity and the amusement of your friends, then you're going to need a couple of things. First is a decent microphone or two, of which there are many out there from brands such as RØDE, Blue, Shure, and Audio-technica. Then you are going to need software to record your podcast and edit it into shape.

There are as many applications made to help with podcasts as there are microphones and subjects to discuss. We're going to look at two of them here: Audacity, which is a free app created by a team of volunteers and released under the GNU General Public License; and Audition, which is part of Adobe's Creative Cloud and therefore comes with all the benefits and pitfalls of commercially developed software – and the Creative Cloud license in particular, which we've discussed before.

Adobe often has a slight

advantage when it comes to choosing software because of the dominant position it holds within the creative industry. People who are subscribers to something like Photoshop default to the Adobe solution, but there's a flourishing ecosystem of free software just an online search away.

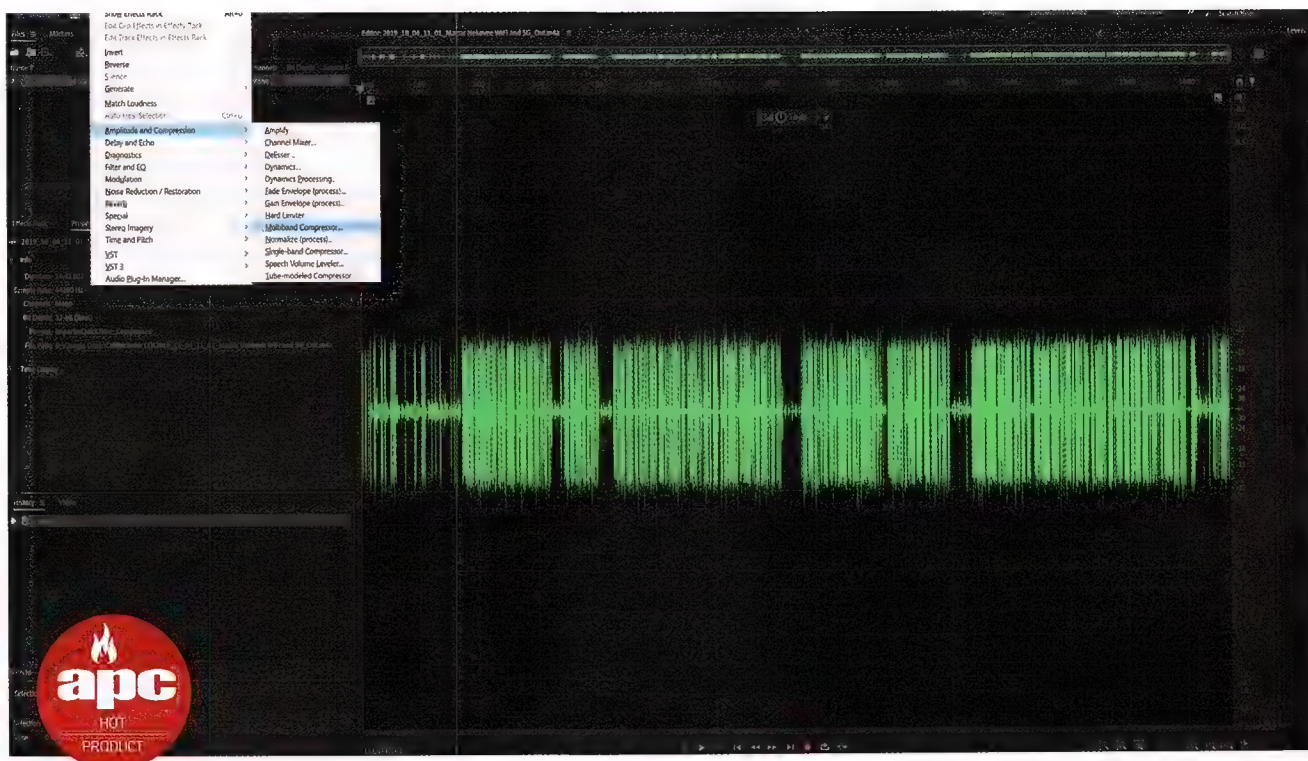
That's where Audacity comes in. Both apps are multi-track audio recorders with editing functions, but where Audition is focused on podcast creation, Audacity attempts to be a bit more of a general-purpose audio solution. Audition has the big bucks behind it, so there's something more polished about its interface, whereas selecting your mic input and beginning to record in Audacity is simplicity itself. The free app also enables you to import an existing recording and record a new track alongside it, as well as starting new tracks automatically when you stop recording and start again. In Audition, you need to choose multi-track recording from the toolbar. Audition does,

Audacity is free, making it the perfect option for those who are just starting out in the podcasting world.

however, make it easier to record the input from different microphones onto different tracks simultaneously – something that's not impossible in Audacity, though it depends on driver support. If you're recording a round-table discussion with multiple mics and participants, Audition is the way to go, as you'll find mixing and editing much easier later on.

Audition also shows stronger performance than Audacity when it comes to actually putting your podcast episode together. Adobe's app uses a non-destructive editing approach similar to its video-editing programs, which means you can always go back to the media bin and replay bits of tape you'd already cut out.

The downside of this is larger file sizes, but modern hard drives should have no problem coping. Audacity offers the option of creating copies of your recordings before you start to edit, which you always should, but it remains that you are editing in a destructive manner, with no way



of getting back cut tape without using the unlimited undo and redo, or re-importing the audio from backups as a new track.

Mixing, particularly the equalisation, limiting, and normalisation processes used to ensure that your various speakers sound like they were recorded in the same room at the same time even if they weren't, is portrayed using a skeuomorphic mixing desk metaphor in both apps, with Audacity showing a waveform that represents your audio, with a number of sliders underneath to adjust the tone. Audition's interface is roughly the same, but it dispenses with the waveform. There are presets in both apps, and Audition's are probably more useful than Audacity's – those in the latter app are aimed at recreating the sounds of voices on the telephone or broadcast on radio.

Normalisation, the process of limiting the volume of the loudest parts of multiple tracks so they sound more alike, sees both apps take a similar approach, with a hard limiter that clips the peaks at a resolution of 1/10th of a decibel. Audition's is easier to use than Audacity's, however, and the same is true of noise reduction, which cuts out any hiss in the background. Both apps can take a few seconds of silent recording and subtract this from the main

Audition has a huge range of features that will appeal to even the most serious podcasters.

tracks, but Audition has a clever adaptive system that analyses files for a better result.

Big boots, small footprint

A great thing about Audacity is that it's very light in terms of hardware footprint. While Audition will only run on a 64-bit version of Windows 10 with a 1080p display, Audacity only seems to care that your PC's power button works – there's a legacy version for CPUs that don't support the Pentium 4's SSE2 extensions – and also runs nicely on a Raspberry Pi.

We always get to a point, when comparing free software to a commercial competitor, where we point to the paymentless option and say "it's free, you lose nothing, just try it out," and that's exactly what you should do with Audacity. It benefits from a long development history, and its interface is one of the best too. If your needs are simple, then Audacity will do what you want, and do it well. We came across a Reddit thread in which one user admitted to using Audacity to record, and Audition to mix and edit, as that's where the apps' different strengths lay. Audacity is simpler, and what it lacks in options it makes up for with a clearer interface.

If Audacity can do something,

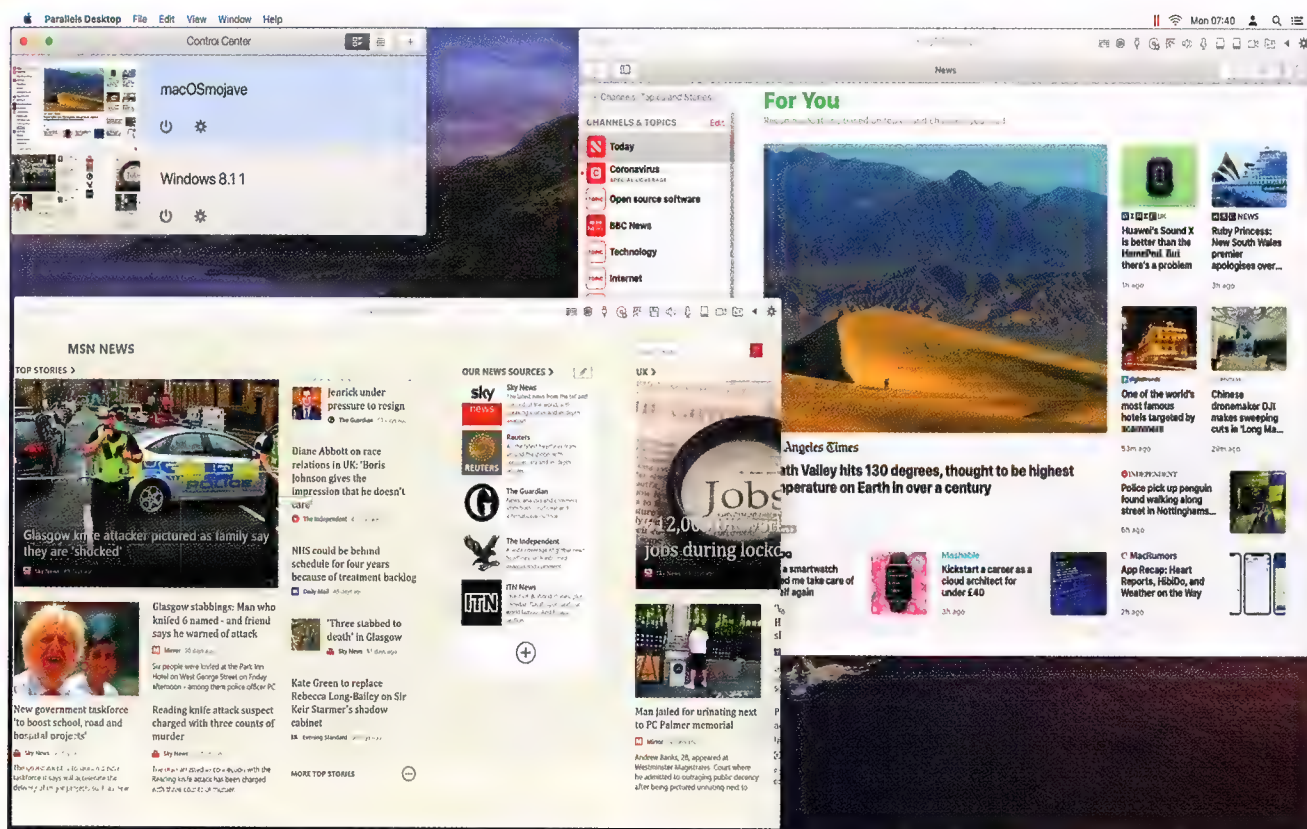
Audition probably does it too, only slightly better. There are features that are exclusive to the Adobe app, as you'd expect for something you pay a monthly fee for (one of which is exporting as an MP3 file, which Audacity doesn't support without the installation of an external encoder). Podcasting is a democratic medium, which has allowed many people with nothing but a laptop and mic, or even a cellphone, to broadcast to the world. Within this structure, an app like Audacity makes sense – its free nature is at one with the podcasting world.

If you're doing it all day, every day, as a producer for a large stable of podcasts, then something like Audition absolutely makes sense. But if you're only just starting out, then there's no reason you can't start and hone your production skills with free software before stepping up later.

IAN EVENDEN

Audacity
It's a free, multi-track audio editor perfect for podcasts and any recording.
★★★★☆

Adobe Audition
Streamlined and polished interface; non-destructive editing; built for podcasts.
★★★★☆



Mac OS X 10.13 or later | from \$109.95 (perpetual home & student) or \$137.45 (annual business edition sub); upgrades \$71.45 (perpetual) | parallels.com

Parallels Desktop 16

Run almost any operating system as a guest on an Intel Mac.

We're now at peak virtualisation. Whichever operating system you want on your Mac, this is the easiest time to go virtual, and version 16 of Parallels Desktop should prove an excellent platform for almost any Intel Mac.

Parallels has long been a convenient way of running Windows on your Mac without having to resort to Boot Camp, although if you have that already installed, Parallels can also run it

as a guest operating system or virtual machine (VM). If you haven't got a copy of Windows 10 to hand, Parallels can download and install it for you, and other methods are demonstrated at bit.ly/MAC357parwin10.

Version 16 brings mostly incremental improvements for Windows users. It's now compatible with more than 200,000 Windows apps, including specialist apps for lighting design and molecular



Above: Guest systems make best use of Retina displays, with further improvements in performance using Metal.

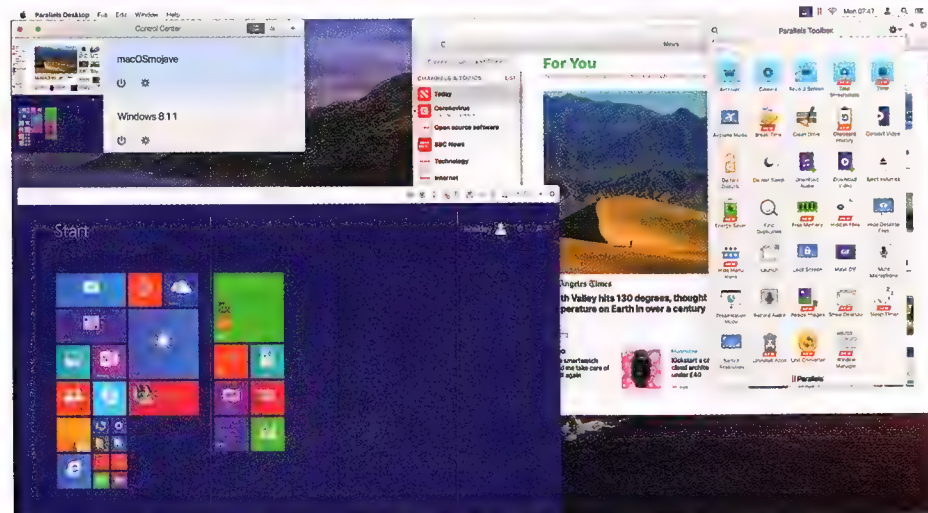
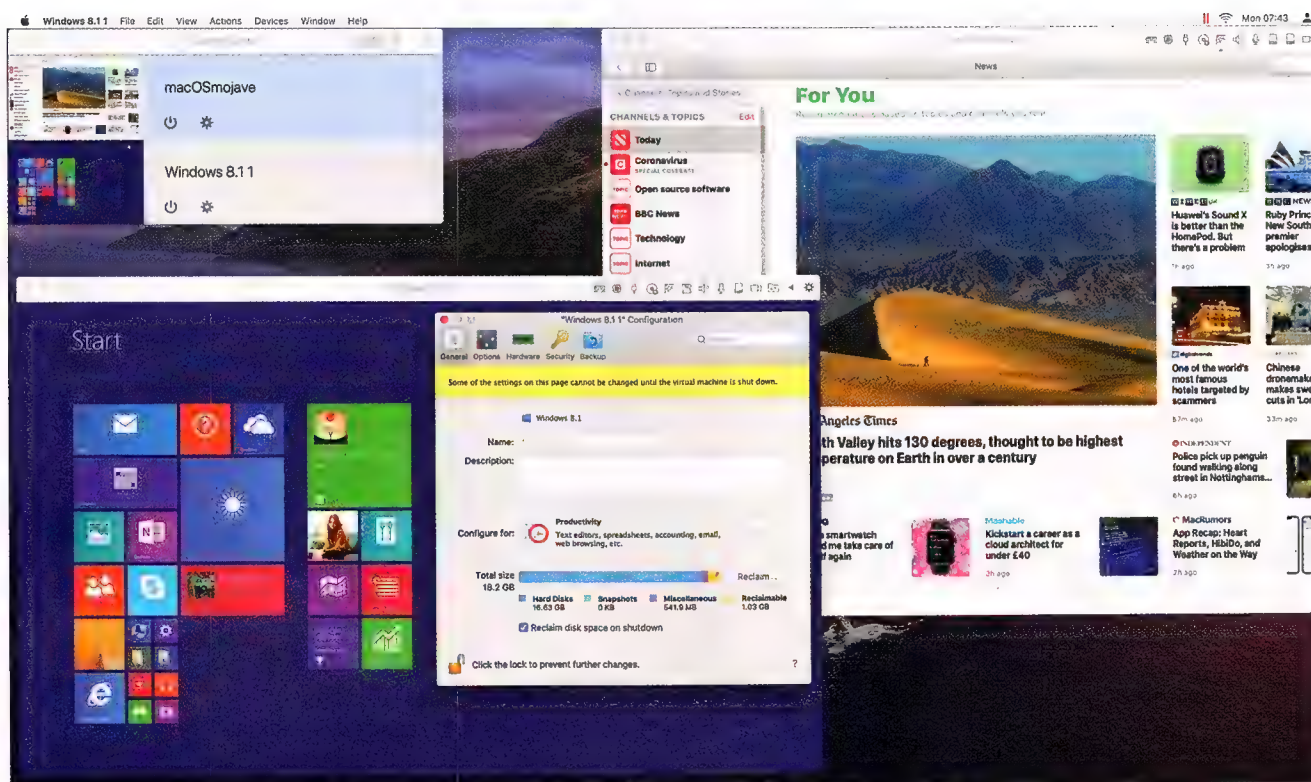
modelling, as well as a great many games. One important advance is that you can opt to have your Windows or macOS VM automatically compacted when it's shut down. When Windows requires temporary additional storage space, that isn't normally returned, causing the VM to grow. This helps keep its size to a minimum, although the process of compaction can take several minutes.

Host Mac host printer features are shared better with Windows guests, making them fully accessible to apps running in a VM. Version 16 further improves performance in DirectX 11 and OpenGL 3 graphics, and there's support for multi-touch gestures in Windows apps too. If you're virtualising on a laptop, Windows Travel Mode is now more efficient in battery usage.

In the past, running macOS as a guest operating system on a Mac has been more unusual, unless you're a software developer or security researcher. Virtualisation has come into its own as the best



Left: Windows 10 and many other guest operating systems are easy to download and install.



Parallels Toolbox for both Windows and Mac also have several minor additions and enhancements.

From here on, though, virtualisation becomes more limited. Because guest operating systems must run native on the processor type in your Mac, what's available is confined to Intel Macs. Virtualisation on an Apple silicon Mac can't therefore run an Intel version of Windows, or – most importantly for many upgrading to Big Sur – an Intel-only release of macOS, and that means anything before macOS 11.

Big Sur's bundled Rosetta 2 doesn't virtualise, but translates code from Intel to ARM instructions so it can then be run on Apple silicon hardware, something that's most unlikely to work for an entire operating system like Mojave. For an Apple silicon Mac to run older versions of macOS or Intel Windows, it's going to require emulation, in which its ARM cores simulate Intel processors. If you want to run Windows apps or older Mac apps which can't run on Apple silicon, you're going to need an Intel Mac with virtualisation. Parallels Desktop 16 is an ideal way to do that.

HOWARD OAKLEY

Easy to set up and use, the first choice for running another OS.

★★★★★

way to be able to upgrade to Catalina or Big Sur while retaining access to apps which are incompatible with those newer versions of macOS, notably any software which isn't available in 64-bit form.

If you're stuck on a Mac running Mojave or earlier because you can't afford to lose access to essential tools, then Parallels Desktop 16 offers the best way forward since it lets you continue running 32-bit apps and software dependent on older kernel extensions that macOS 11 Big Sur won't tolerate. This is particularly beneficial if you're still using an older version of macOS to support macOS Server.

Even running a Big Sur guest on a Big Sur host Mac has its attractions, with added support for 3D graphics in Metal. Performance is generally close to that of the host hardware: on a Mac with an Intel Core i9 processor, most apps should run at a speed similar to a Core i7 or better, and the more expensive Pro and Business editions let you improve on that by virtualising on more than two cores when you wish.

General improvements in version 16 include faster launching of guest operating systems, and for those running Linux VMs 'git status' on a repository is much quicker than previously. The essential companion tools in

Top: There's a new option to reclaim storage when you shut a guest system down.

Free (IAPs) | linea-app.com | NEEDS iOS 12.4 or later

Linea Sketch 3

A universal drawing app for iOS.

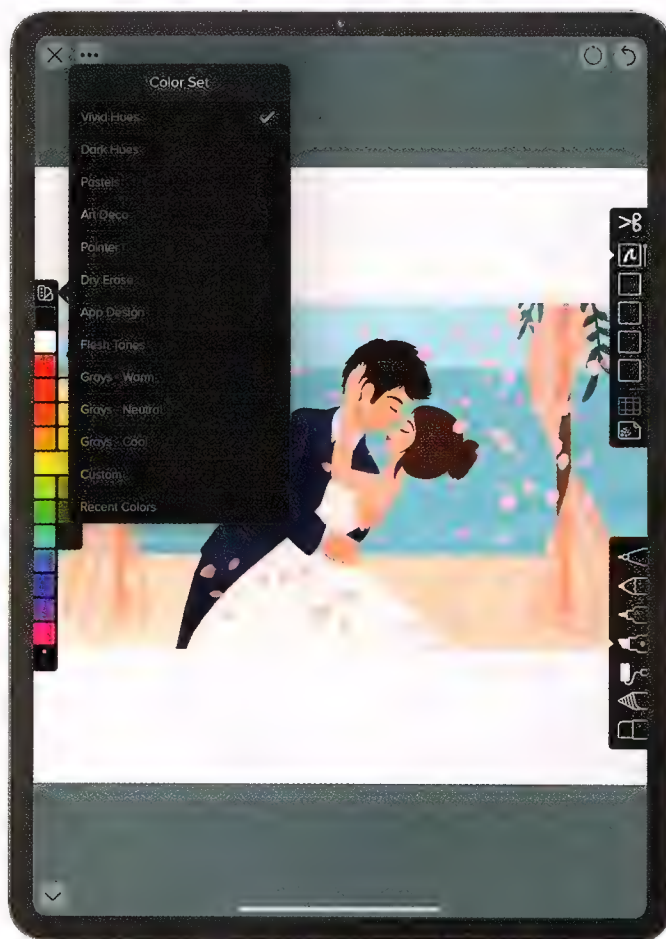
iOS devices are excellent tools for creating graphics when paired with the best apps for the job. Linea Sketch is a vector drawing app with comprehensive support for the Apple Pencil, including its unique double-tap function, but of course it also works well if you use a finger to draw.

Version 3 makes the app universal across all supported iOS devices, although Apple Pencil support is only on the iPad version. iCloud sync means that you can easily pick up a project in progress from any device at any time.

Tools and time-lapse

It's a beautifully simple app with a range of custom canvas sizes. And now it also has custom background colours, including paper textures, which look great on the screen. The app itself can also now be themed, changing its interface colours and even home screen icon. The toolbar appears along the right-hand edge in whatever orientation you're using, and there are five layers available. Some people might prefer more, but that should be enough for most. Below this is a selector for your pen or brush style. Tapping and holding on any tool for a second calls up its contextual menu where you can choose hardness, size, and other parameters. It's possible to import any image into a layer using the same technique, which is very useful for drawing over an existing image.

You can record time-lapse video of your work, or even broadcast your drawing work live.



The colour palette on the left is extensive, with sets as well as variations on individual colours. A nifty feature helps you to draw shapes – simply draw the best version of, say, a triangle that you can, then keep holding your finger down. The app will automatically turn it into a perfect triangle, with handles so you can easily move or resize it.

Similarly, with the Cut tool you can draw freehand around any

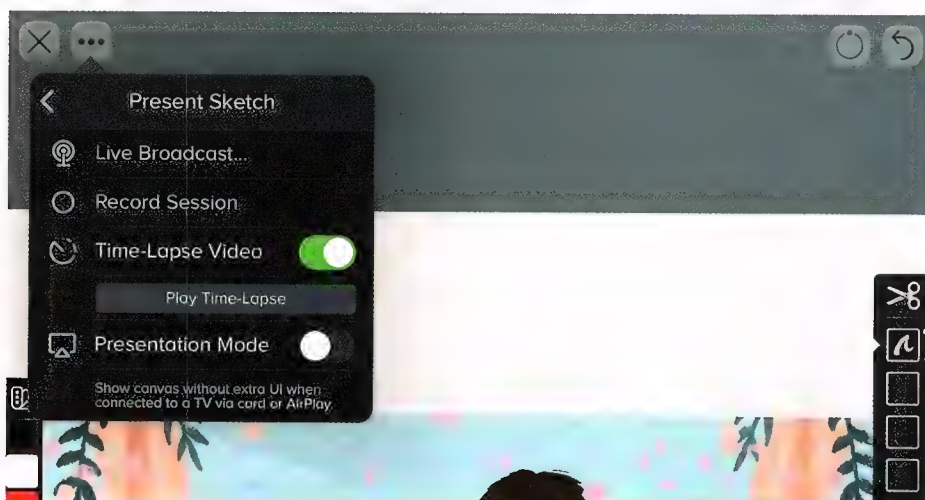
content and it gets selected to be moved or resized. A new feature, QuickToggle, gives further help with making regular shapes. Start drawing a line and rest a second finger on the screen. The app snaps the line perfectly straight, and you can rotate it around an anchor point.

Another major new feature is time-lapse recording. Artists and designers often want to show how they create a project, but the process is far too long for a regular video. When activated it snapshots the stages of your project – this can be paused – and the results are exported as a 30-second or full-length video. You can even crop the canvas before you export. Other recording options are available too, like the option to broadcast live to YouTube directly from the app. Even if you make time-lapses of your creations purely for your own records or amusement, it's a great new feature and very well integrated.

HOLLIN JONES

A gorgeous drawing app for users of all skill levels, with great new features.

★★★★☆



NEEDS iOS 12.2 or later | Free (IAPs) | [ulysses.app](#)

Ulysses 19.2

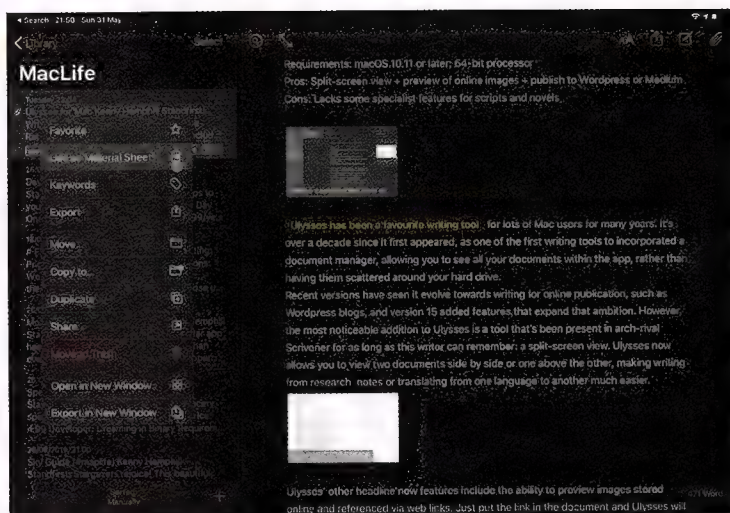
Veteran iOS text editor is upgraded.

Ulysses was one of the first text editors to exploit the potential of the iPad. Since then, it's been joined by several others, but few are as elegant as this app.

One of the key new features supports the latest development in iPadOS – improved support for mice and trackpads, so you can now use those with Ulysses. You can also access external folders through the Files app, on both iPad and iPhone.

Previously, every word in every Sheet in a group was exported when you exported a group to, say, PDF or eBook, and every word counted towards the overall word count and other statistics. In this version, you can now designate Sheets as 'material', which are essentially research notes. This tells Ulysses to ignore the sheet in statistics and when you export.

There's support now for keywords in Markdown files. Other new features include new filter



criteria, the ability to import and export backups and, in a nod to coronavirus, the addition of a roll of toilet paper to the icons library!

Ulysses is a multipurpose text editor. It doesn't have Scrivener's

corkboard, but it offers PDF, ebook and HTML export, and you can post to WordPress and Ghost.

KENNY HEMPHILL

A solid upgrade to a top text editor.

★★★★★

NEEDS iOS 9 or later | \$2.99 | [crescentmoongames.com](#)

Alter: Between Two Worlds

Brains meet beauty

There are plenty of beautiful puzzle games, but not all are as challenging as Alter. Each level comprises two worlds, which you can switch between when you stand on portal tiles. The trick is to manipulate your surroundings in one world so that you can reach the goal in the other.

Alter uses this mechanic well. Pushing a block onto a square in one world may trigger a moving platform in the other. An enemy in one zone may prove an ally in another. You have to consider not only your present state but how things will affect the alternate reality. The results are mind-bending, with perplexing puzzles at the beginning ramping up to serious head-scratchers by the end. Completing each level feels especially rewarding.



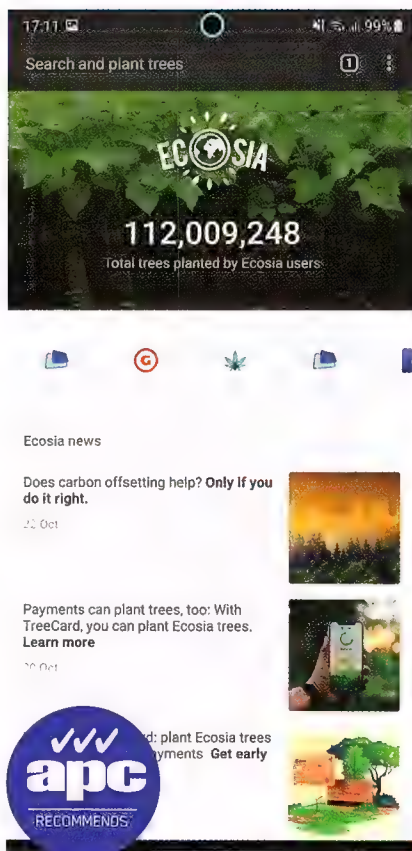
The only shortcoming lies in the narrative. Who is Ana, your protagonist? Why is she trapped in this dangerous world? These questions remain largely unanswered, which is a bit of a shame. Ultimately, though, Alter's gorgeous graphics and layered

puzzles shine through to make it an instant classic.

ALEX BLAKE

A fairly short puzzler, but one that will live long in the memory.

★★★★★



Android

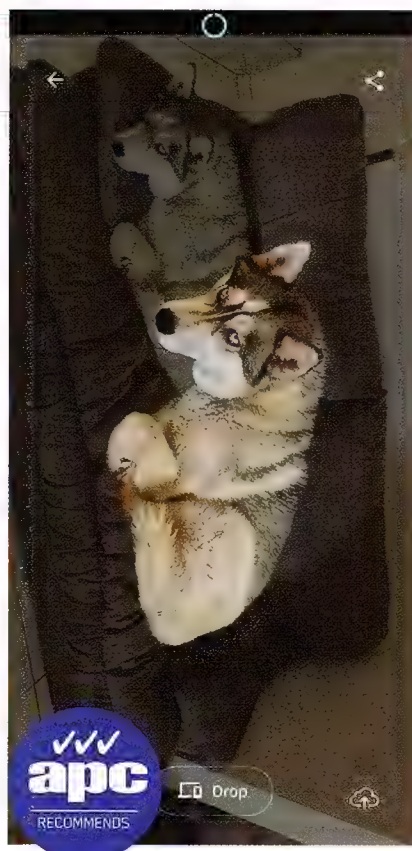
Ecosia - Trees & Privacy

Curiositrees

Free

If you, like me, use your phone as a device that can answer any and all your random questions by Googling, then you should probably pick up Ecosia (and it's also excellent on a Mac or PC). It's just a browser and web search app, but it uses the ad revenue from searches to plant trees. I did a bit of digging and for all I can tell it looks like the money is actually going where they say it goes, which is honestly kind of incredible. At the bottom of the home screen of the app they have links to financial reports and all sorts. I've been using Ecosia as my default searching browser for a month and so far it's been fairly good. Once or twice I've swapped back to Google when not finding results or to have it in my Chrome history, but for the most part Ecosia has handled all of my searching needs. Here's hoping my abundance of stupid curiosity will finally do some good, and yours could too.

★★★★★



Android

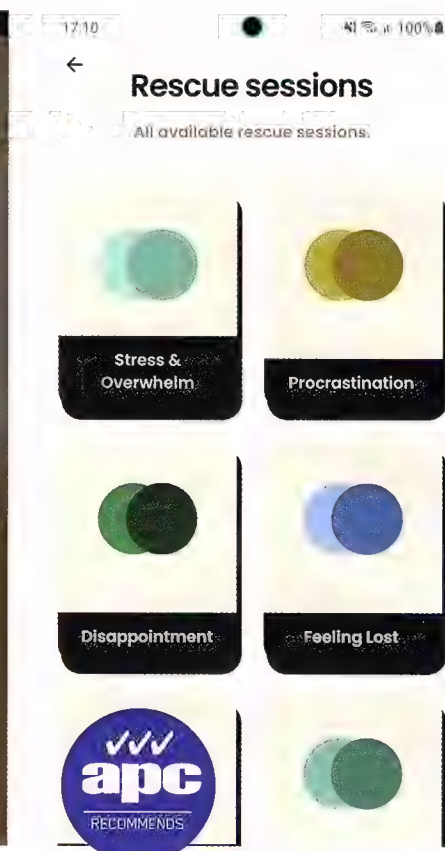
ClipDrop - AR Copy Paste

Instant images.

Free trial/\$14.99 per month / \$49.99 per year

ClipDrop is the coolest AR app I've played with that I can see myself using more than once. It's surprisingly simple. Just take a picture of something, it crops out the background (or not, if you don't want it to), and you can even drop that straight to your PC or just save it to the cloud. There are limits on how many cut out images you can try for free, but it gives you a fair idea of whether or not the app feels worth spending money on. It does a surprisingly good job of the cuts too. I tried it on my dogs and it doesn't cut around every individual hair perfectly, but it gets the general idea really well – well enough I couldn't have touched it up better, especially on my phone. I tried with solid objects like figurines and they came out beautifully cropped. I've often spent far too long trying to achieve similar results in a much less cool way but \$50 a year feels a bit rich.

★★★★★



Android

Intellect: Create a Better You

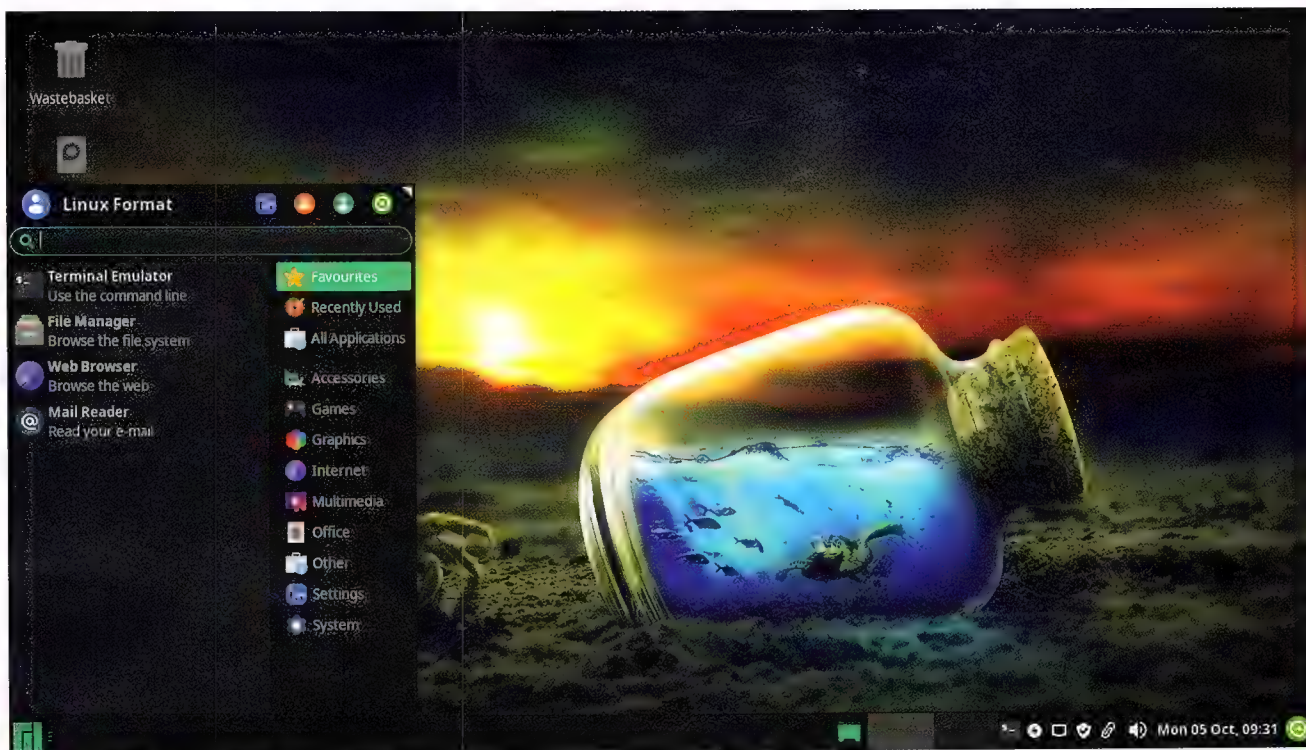
Or die trying.

Free

Intellect is free and has no ads on Android, which immediately sets it far apart from other self help apps. When you start Intellect for the first time it has you answer some questions about yourself and gives you an analysis on your psychological profile. Honestly most apps charge to get this far alone, so if you're wanting a self help type program to delve into, Intellect seems a good choice. It offers a space to journal and track your wellbeing, as well as lessons around different aspects of your life you may want to improve. Something I really like that is more than worth the no cost of admission are the Rescue Sessions. These are super quick little lessons you can go through that take around three to five minutes. They're designed to get you through a moment. So if you're procrastinating, or having a down moment, Intellect may just help you get out of it and on to the next, hopefully better moment.

★★★★★

HOPE CORRIGAN



Linux | www.manjaro.org

Manjaro 20.1.1

The distribution that brought Arch to the masses continues to amass new features and win over Jonni Bidwell, who's never easily pleased.

The release of Manjaro 20.0 back in April evaded the eyes of our vigilant review team, so we made sure this 20.1 "Mikah" release got the once-over. Manjaro follows a rolling-release model, so current Manjaro users don't need to reinstall unless their current install is broken. Anyone who perhaps has dabbled with Ubuntu or Linux Mint though, should certainly consider firing up this ISO. Manjaro continues to push the Xfce edition as its flagship, so we'll focus on that here.

The Calamares installer is as polished as ever and enables you to set up a swap partition with hibernation support. It also continues to offer you a choice of office suite: LibreOffice, FreeOffice or none of the above. FreeOffice is a proprietary product that the Manjaro team believes offers the best compatibility with Microsoft Office. If you install with no office suite, the initial install weighs in at 6GB.

The Kvantum theme engine is included and ensures Qt5 applications will match the rest of the desktop, which uses the Matcha theme. The fetching blue and green sea variant, to be precise. Manjaro prides itself on customisability, so there are alternative themes and other dials

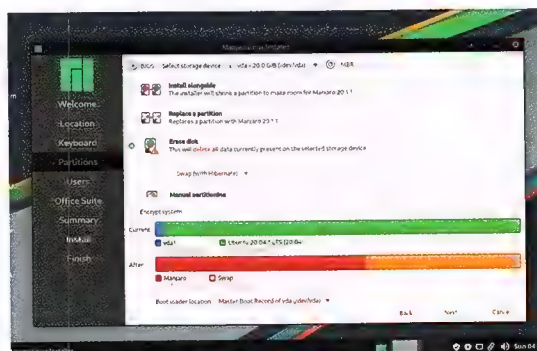
and frobs to tinker with. One such is the kernel tool, which makes it easy to switch to the latest RC from **kernel.org**, a real-time kernel or an LTS release.

Manjaro also strives for usability and Hello, its welcome tool is polished and indeed extremely welcoming. There are the usual web links, but lots of information (release notes and information on joining the project) is available within the utility itself. The applications browser section is tidy and doesn't overwhelm the user. Rather, it enables them to explore some better-known programs and get them installed in a few clicks. Pamac, Manjaro's graphical package manager, has been updated and under the hood now has faster dependency checking and handling. Pamac can

Did we mention there are some truly wonderful desktop backgrounds in Manjaro?



Manjaro can easily set up features during installation.



work with Snaps and Flatpaks, as well as (if your willing to brave user contributed packages) the Arch User Repository (AUR).

Manjaro comes with a fine selection of software. Steam, VLC and the HP Device Manager are all ready to go. Users used to the Ctrl-Alt-T shortcut for opening a terminal window may get a bit of a surprise because this will open a drop-down window rather than a conventional one. We think drop-down terminals (like Guake and Yakuake) don't get nearly enough attention, so this is a nice touch. The Timeshift system restore utility is included (as in Linux Mint), which might one day save you from a deadly AUR package update.

Further work has gone into the display configuration dialog, which will be good news for people with multi-display set ups. You can define different profiles for different set ups, and these profiles can be automatically applied as hardware is connected.

We're thrilled that Manjaro continues to embrace Xfce, but if it's not your thing do consider checking out the other releases. The KDE release, now featuring KDE 5.19, is proving most popular on the interwebs. **JONNI BIDWELL**

One of the best distros for people wanting fresher packages or a deeper understanding of all things Linux.

★★★★☆



FEATURE

Mechanical Mysteries

Dave Alcock takes you on a journey through the realm of clickety keyboards.





Keyboards are the true kings of input devices. They predate mice by almost 15 years, and thanks to companies like IBM – which set the standard in terms of the shape we know today – they have become perhaps the most easily recognisable and usable devices out there. In fact that tell-tale shape ensures that we can jump onto any PC we see and immediately know how to interact with it. If you think of a keyboard, you usually end up with an image of that standard 104/105-key ANSI layout imprinted into your mind.

Membrane, dome, capacitive, and scissor-switch keyboards still make up the majority of the keyboards that are out there in the wild today, mostly due to office and industry use. But before we go any further on this, what we will say is that these boards are perfectly fine products. There is a reason they are still being

used in such vast numbers right now, and that's because they're cheap, accurate, and do the job they're designed to do darn well.

However, if you want to take it a step further, there are of course mechanical keyboards. These are nothing new – in fact most early keyboards were mechanical, with many phased out in favor of the cheaper options we just mentioned. The IBM Model M and Model F were the most sought-after of the older mechanical boards back in the day, and almost 30 or 40 years later these buckling-spring bundles of joy are still priced high enough to make your eyes water, coveted by many a coder and developer, even at APC. So let's dive a little deeper into the world of the mechanical keyboard.



Mechanical keyboards vs everything else

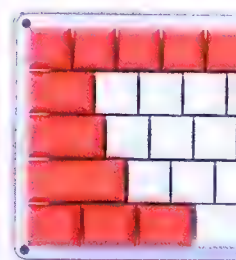
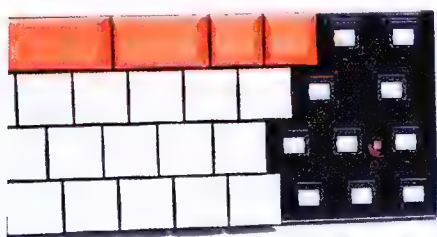
So what is the difference, then? Well compared to other keyboards, mechanical switches are just that: Mechanical. They have a mechanism inside that moves and creates the action that sends the key-press signal. How this happens changes slightly depending on the switch type, but we will cover this in more detail later on.

The most common PC keyboards are membrane keyboards, while dome boards are still seen in industry quite a lot as well. Membrane keyboards use three layers, with the middle layer just there to space apart the top and bottom conductive layers so that they are not sending a signal to each other constantly. Once you press the key-switch down, the top and the bottom layers touch, complete a circuit, and send a signal. There is no mechanical action involved.

Dome keys are similar to membrane ones, but they have a dome that collapses to give the user some tactile feedback. There are also hybrids, known as memmechanical (or membranical, depending on which

marketing guru you listen to) keyboards, which are membrane boards that use a clicker to make them feel somewhat similar to mechanical keyboards. This keeps the price down but doesn't really give the user any benefits over the feeling of using the keys.

Mechanical switches are preferred over other switches because of their reliability, repeatability, and stability. If it has "ability" at the end, a mechanical switch probably does it better than the rest. Mechanical switches have far tighter tolerances, and they should feel more consistent between each other compared to other switch types. This enables users to really get a preference over what they like to use, and this can then improve productivity or performance in gaming.



PREBUILT VS CUSTOM KEYBOARDS

Prebuilt keyboards are off-the-shelf boards. These are the most common examples of keyboard on the market, and are by far the easiest to acquire. If you are new to mechanical keyboards, they are probably the best option, as well as for those who just want to buy a board and use it.

These include more popular brands, such as Corsair, Logitech, SteelSeries, Razer, and many more. There is nothing wrong with these boards, and if you're an avid reader, you will see that these are the products that we use and review more often than not; they are readily available, and we can review them within certain parameters and testing criteria in a balanced manner.

Custom keyboards, on the other hand, are completely down to the user. They are bought either in parts or as kits, and can really be anything you want them to be. Custom keyboards also open up the possibilities to move away from the standard shapes, sizes, and layouts that we usually see, enabling you to create something more unique, ergonomic, or just bespoke to you.



"Custom keyboards also open up the possibilities to move away from the standard shapes, sizes, and layouts that we usually see, enabling you to create something more unique, ergonomic, or just bespoke to you."

Keyboard sizes



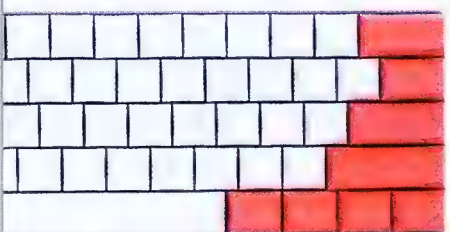
A full-sized ANSI (American Standard) keyboard.



Full-sized keyboard without tenkey or numpad.



A 65 percent board gets even smaller.



60 percent boards: Now you have no physical arrow keys either.



40 percent is a little bit strange. These 44-48 key beauties are tiny.

Full size

A full-sized ANSI (American Standard) keyboard has 104/105 switches, usually. The numpad on the right-hand side enables you to input numerical data easily, and companies can often further increase this size by adding macro keys or media keys to the board too. This means that the keyboard has a large footprint on your desk, often dominates your workspace, and can quite easily create an uncomfortable ergonomic working position.

If you use these boards, you will likely sit with your shoulders in a slightly wider position than with a better ergonomically designed board. This is a natural process, and one you do to ensure you don't hit the keyboard with the mouse. It's actually almost unnoticeable, as these are typically the boards many people grew up with, and it became second nature to use. These ergonomic problems only became apparent, as a curious discovery, once people started to use smaller keyboards.

TKL (Tenkeyless)

As the name suggests, this is essentially a full-sized keyboard but without the tenkey or numpad. This reduces the size a great deal and also puts you into a better typing position, as now you can move the keyboard slightly towards the mouse, and your arms can be in line with your shoulders, with just a slight bend at the elbow creating the optimal sitting position. The difference isn't worth changing keyboards for though, and for many users the numpad is far more useful than having a slightly smaller board.

65% keyboard

A 65 percent keyboard gets even smaller. This compresses everything down more, and you lose the physical F-key row as well. That said, you can still access them by using the FN key + the number keys, and the arrow keys are still physically there but are far closer to the right Shift/Control buttons. This is a good sweet spot for those who want a compact board but still want to use it without too many compromises.

60 percent keyboard

60 percent boards go one step further over the 65 percent ones, removing physical arrow keys too. Instead, the arrow keys are usually used with FN + IJKL or PL;'. You can also usually rebind these to other letter combinations, if you so desire. When it comes to our own custom keyboards, we have more 60 percent boards than anything else. It takes some getting used to, but once you do, workflow is just as fast, and you have a far smaller footprint on the desk. You can also shove a 60 percent keyboard into a laptop bag easily and carry it to events with you, meaning that typing away from the office or home has exactly the same feeling.

40 percent keyboard

40 percent is where it gets a little bit strange. These 44-48 key beauties are tiny. Boards like the Vortexgear Core 40 and the Planck have made these more popular, but they are still very much a niche, enthusiast product. They can still function as a full-sized board: Nothing is missing from it, you just have to remember the layers and the different functions. These are more of a hobby board, certainly until you get used to them, and even when you do, they're not easy to use in terms of functionality for anyone who does office tasks, or similar jobs that may require different punctuation on occasion. You'll spend more time looking for the right key than actually typing. We know from experience.

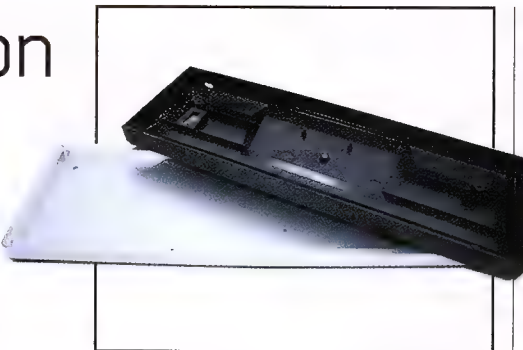
Split keyboard

As well as all the standard sizes we listed above, there are also split keyboards. These usually follow a TKL or 60 percent layout, but there are also full-sized split boards available too. Split keyboards link back to the ergonomics of peripherals, and instead of forcing your arms into a triangle like a standard keyboard would, these enable you to split the left and right sides apart so that you can sit optimally. There's a reason a car's steering wheel is still quite large: Sure it helps you to make turns, but the position it forces you to sit in with your arms is better for you. Split boards are based on a similar theory.

Keyboard construction

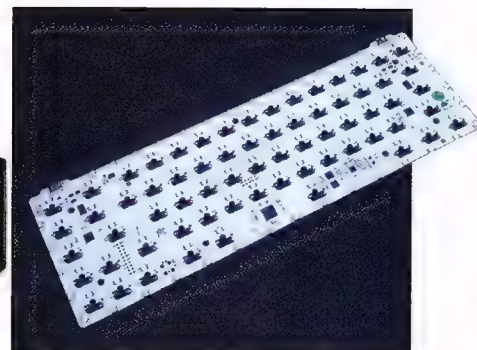
We won't go too much into the construction of a keyboard, but we do want to take a quick detour here, and it's something we intend to cover in much more detail in the future. In fact we'll be bringing you a series of guides on how to build your own custom keyboard later on this year.

Most custom and prebuilt keyboards use very similar components, certainly until you delve into the world of DIY componentry – which let's just say we'll stay away from for now. Purists often buy parts according to their preference on size, materials, and how well noise will resonate through them. Tinny, horrible-sounding switches are frowned upon, and when used even with a well-constructed keyboard can leave you with a hollow experience. So choosing the right parts is critical. If you're after a satisfying clunk, that perfect tactile component, and an almost-silent typing board, then a linear setup is the way to go. So what parts are there, and where do you begin?



Case

The main part of the keyboard is the case or housing that will hold all the componentry. These are usually plastic, especially when you buy an off-the-shelf keyboard from mainstream brands, although in the custom market metal is starting to become more common. For custom boards, resin, wood, and 3D-printed cases are also added to the mix. Basically anything that can be used as a case will be used as a case – even Lego. The case simply keeps the internals protected and enables you to create an incline if you so wish.



PCB

The PCB or Printed Circuit Board forms the electronics side of things. A PCB keeps everything neat and tidy and enables switches to be soldered to it easily. For off-the-shelf and most custom boards there is no real difference here. For component-level DIY boards, however, you can use remarkably simple PCBs or even do away with them entirely and wire everything by hand. Keyboards are not as complicated as they seem, and with a mini Arduino (or similar board), some diodes, a few resistors, plenty of switches, LEDs, and wires, you're basically good to go.

Switches

Fasten your seatbelts and get comfortable, because this is where mechanical keyboards really get interesting. Perhaps the biggest cause of all arguments in the keyboard community comes down to that one fateful question: "Which keyboard switch is best?" None of them. That's right. There is no such thing as "the best switch," don't let any online keyboard buyer's guide tell you otherwise. Anyone who is telling you that is simply wrong. It also goes for brands: Cherry does not unequivocally make the best keyboard switches, it's just one of the most popular and common brands out there. That's not to say Cherry switches are bad, just they might not be the perfect switch for you.

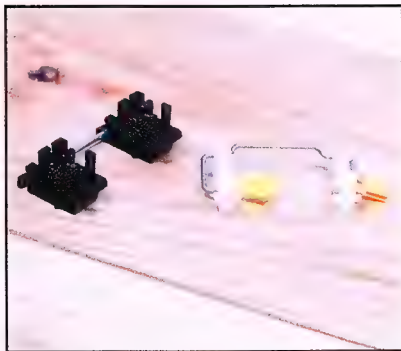
We won't go into every brand and switch here, as there are literally thousands, but we can go through the types of switch and a few terms so that you can understand what we bang on about in reviews.





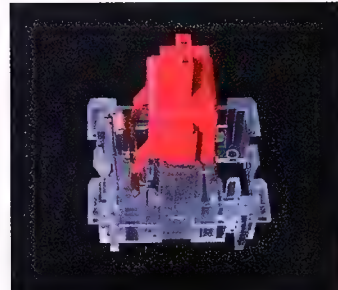
Plates

Plates are not seen in all keyboards but they exist in most, one way or another. There are many different types of plate, from top-mount to drop-in plates, but essentially all you need to know is that they are there to help with mounting the switches to the PCB, and also giving the keyboard some additional strength, noise dampening, and a desired level of flex. You might be incredibly surprised how different keyboard parts can completely change the noise levels and pitch of the switches that are installed, and a plate is one of those parts.



Stabilisers

There are also stabilisers, and as the name suggests, these stabilise the keycaps so that they press down smoothly. These are only needed on large switches, such as the Spacebar, Shift key, and Backspace. There are a few different types of stabiliser, but the main two are Cherry style and Costar style. Unless you're building your own keyboard or you're thinking about modding a keyboard, it really doesn't matter which stabilisers are in your keyboard. If you do get a choice, though, try and stick with Cherry style as they are far easier to work with.



Switch terminology

Different switches have other important statistics, beyond just the operating force.

Tactile

Tactile means that there is a physical bump as you press the switch down. This is usually caused by the leaf and plunger interacting, or the plunger interacting on its own. Cherry MX Browns are a good example of this.

Linear

Linear switches are straight up/straight down switches. They don't have any tactile feedback at all. Cherry MX Reds are one such example.

Clicky

Clicky switches do just as the name suggests: Click. This is what will annoy your co-workers in an open-plan office, and potentially give you a lot of enjoyment. The click usually coincides with tactile switches, as found in a Cherry MX Blue switch.

Actuation

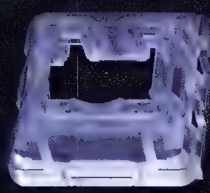
Actuation defines at which point in the switch's travel it sends the signal that it has been pressed. This actually changes between switches too. A switch such as a Cherry MX Speed Silver has 1.2mm until the actuation point with a total travel distance of 3.4mm. Something like a Cherry MX Blue will travel 2.2mm before the actuation point, and will travel to 4mm in total. This means that you don't actually need to bottom-out switches when typing, and you can keep noise down while still activating them.



Popular switch brands

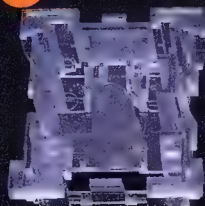
Cherry
Kailh
Outemu
Gateron
Zealios
Romer-G
Titan
Topre
Alps
Razer

Switch Construction



01 Switch housing

The switch housing is the case that encapsulates all the internal parts. The tops are usually clear plastic now, so that RGB lighting is brighter. The bottoms can be any colour. Most switch housings are very similar as they follow a standard, enabling you to swap them out easily. There are also two types of switch mounting. PCB-mounted switches have two additional prongs on the bottom of the switch that grips into the PCB. These make the switch more stable. Plate-mounted switches don't have these prongs as they grip onto the plate of the keyboard. This is usually a little bit less stable and can often give the switch an additional wobbly feel.



02 Stem

The stem on the switch is the little plastic plunger. The keycap attaches to this part. The most common stem is the Cherry MX style "+" shape. There are other kinds though: Topre uses an "O" shape, and in the past Kailh has used boxes. Now the majority of stems are using the Cherry + shape - it is far easier to get keycaps for these that fit a wide range of switches.



03 Spring

The spring is what gives the switch its resistance or weight, and it is also this that resets the key after each press. The weight in these springs is measured in cN (centinewtons), but this is very close to grams: 1 cN



04 Leaf

The leaf inside the switch is a thin piece of copper, folded in such a way that when the stem is pressed it will complete a circuit and send the signal saying the switch has been pressed. This can also be used to give the switch a tactile feedback, and make those signature clicky sounds. In some switches, however, click bars are used for this. Different thicknesses are used by different manufacturers, and the tolerances between them can change significantly, especially on cheaper

switches, which will increase or decrease a switch's long-term durability.

Switch colours

You will often hear a colour attached to the brand of switch, for example Cherry MX Greens, or Kailh Reds. This denotes the specification of the switch. The colours are not universal over different brands: A Kailh Brown is weighted at 45cN, whereas a Cherry MX Brown is 55cN. 10 cN is a big difference in terms of switch feel, so it is worth trying out a board with the weighting you're curious about before you commit to buying it.



Printing Types

Double shot

Double-shot keycaps are created by melting two different plastics and moulding them into each other. This means that you have one colour as the main keycap housing, while the second colour becomes the legend.

Pad printing

Pad printing is probably the cheapest and easiest method of printing the legend, so it is more commonly seen on ABS caps. It is actually just a thin layer of paint on top of the main bulk plastic of the keycap, so it can be worn off over time. It does mean that more than just one colour can be used, though.

Dye sublimation

A very expensive and time-consuming method is dye-sublimation printing. With this method, an image is printed onto transfer paper, then heated along with the keycap so it is transferred over. Although difficult to do, it does mean that you can use multiple colours. It also comes with some caveats. For one, you can't print onto darker keys very well, unless the image is darker than the key itself. Due to this, it is usually used with white or beige keys only.



Keycap materials

Keycaps sit on top of the switch and are usually made from a form of plastic. There are many different types of keycap, from ABS to PBT, which can be printed on in different ways. We won't go through all the types, just the main few. It might sound complicated, but it really isn't when you break the terms down. The keycaps can change the sound of a keyboard immensely, and will affect the feel of the board and your typing experience.

ABS

These are the most common switches available on the market. The plastic is very soft and cheap, and they can have the text (legend) printed on them in many different ways, such as pad printing, or double shot.

PBT

PBT keycaps are seen as superior to ABS, because they don't usually get as shiny and are often thicker. They also have a nicer texture. Again, these can be double shot, but dye sublimation is often used as well.

Why bother?

Why should you spend silly amounts of money on custom keyboards? Why spend \$30 per switch when there can be anything from 40 to 120 switches on a keyboard, and then put \$80 keycaps on them? Just, why?

Well, the answer really is a mix of searching for perfection, the desire to be able to show off to fellow keyboard enthusiasts, trying to create something unique, wanting a fun hobby, and simply because it is pretty.

No company will ever be able to create a keyboard that will be perfect for everyone. Everyone's needs and tastes are so unique that it's just not possible. And their preference of what to type on can change over time.

Most of us have keyboards, yet many of us take them for granted. They're unique, they change over time, and what we like the sound of develops and evolves. There is a lot more to think about with keyboards than it first appears.

Artisan keycaps

This is where things start to get into the realms of "just because we can." Artisan keycaps are the next level of craziness. As you can see, these can be anything you imagine. Do you have two cats and love the colours white and orange? No problem, commission Esquimo Keycaps to make custom kitty caps and slap them onto your board. Sure, you just lost \$150, but you feel happy and you have something that no one else in the world has.

Alternatively, do you want to encapsulate the horrible fidget-spinner trend on your keyboard? No problem, Hammer has these for US\$30. These unique, handmade keycaps have no other use than to look pretty and ensure that you have no money left to get you into trouble. We know this. We understand they're a waste of money. We just need more. More! ■



FEATURE

Testing Nano Coolant

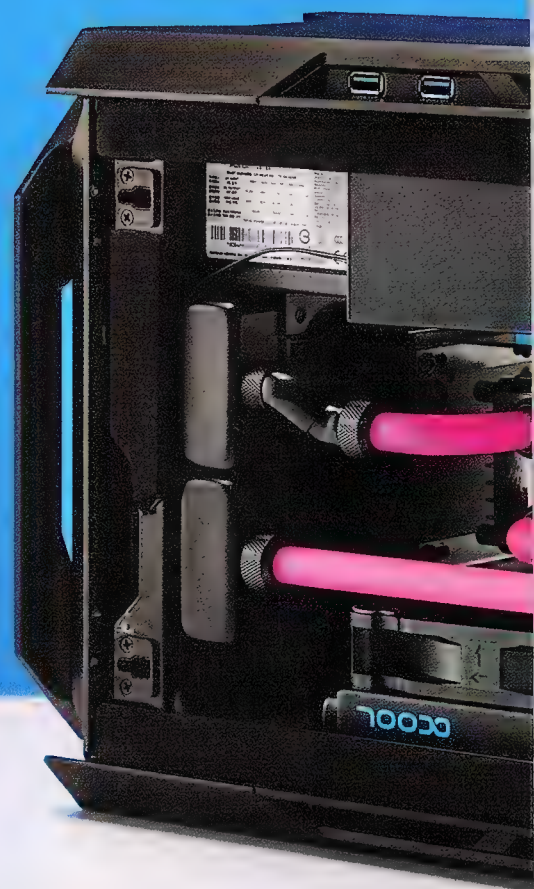
We get hands on with one of the world's most advanced liquid coolants

We know what you're thinking: "This is odd." And you're right – it's not something we'd usually cover here at APC. No, this is something we've never done before: A case study and the chance to test something that very few people can get their hands on.

So, what are we talking about? Well, we're heading back into the world of tubing and water blocks to take a look at one of the most radical types of coolant being developed and grown today: Mayhems' 6nm XTR. Yes, you read that right – this coolant is synthetically grown in a lab. It's unlike any coolant we've ever seen before.

However, there's a few problems we need to overcome before we get to the testing phase. Firstly, as the APC office is currently shut, there's only one machine we still have access to that's capable of performing the tests we need: Our console-esque pink PC, which was designed for its aesthetics, with usability a secondary consideration. So, it doesn't have a proper drain port nor a fill port, and we've got some serious conversion problems to solve.

But before all that, let's dive into the history of liquid cooling, how it developed, and where it's likely to go from here.





1ltr XTR
TREATED

1ltr XTR
TREATED

HD-BLACK
SN750

PHANTEKS

ACER
Eisbaek GPX-N 2080 Ti / 2080 M02



Kings of cooling

The problem with PCs.

No matter how you look at computing performance, it always boils down to electricity, tolerances, and heat. Those three factors have stymied unlimited power over the years. Diminishing returns are rife within this hobby of ours. As transistor count goes up, gate width decreases, more voltage is applied, and heat increases, the need to cool components becomes more important to ensure they remain within their operating temperatures. To draw heat away from the processor and into something that can dissipate it into the open air has been of prime importance since the personal computer became a thing – in fact, even before that, with supercomputers.

The basic principle behind cooling any PC component is that you need a form of heat exchange to take heat from the system and dump it into the surrounding environment. Nowadays, you have a handful of options. Firstly, you could go with low-powered, efficient components (such as the Raspberry Pi), which can be passively cooled. Or you could run with an air tower that thrives off heat pipes, vapor chambers, and the brilliance of convection. You could also go with a basic form of liquid cooling in the form of an AIO (all-in-one) cooler from the likes of Corsair, Nzxt, Cooler Master, et al. Or you could build your own complete custom liquid-cooled loop to chill everything within sight, albeit at far greater expense and risk if something goes wrong.

The Basics

Almost all of those options (bar passive cooling in ultra-low-powered chips) rely on a form of heat exchange or phase change to remove that excess heat. Take your standard CPU tower, air-cooled with a fan. By design, they typically have a solid, flat copper or nickel base, with heat pipes emanating out and up into a tower, which is then covered in an array of fins. This is then cooled by a fan, that's either pushing or pulling a stream of cooler air over the fins, drawing that heat out.

This works through the power of convection. Each heat pipe or

vapor chamber houses a small amount of liquid. When the processor is under load, it heats this liquid, which evaporates, forming a gas. Drawing the heat with it, it rises up through the heat pipe toward the fins. Here, cool air passes over the fins, drawing the heat out of the gas through the fins. The gas then condenses, changing back to a liquid, and flows down to the base of the heat pipe, ready to start the procedure all over again, very much in a loop. This is, in essence, a form of phase-change cooling, although not quite to the degree of some more extreme methods achieved by using a proper vapor condenser.

A liquid-cooled loop follows a near identical principle, just scaled up. Instead of heat pipes, you have tubing; rather than a copper base, you have a water block; instead of

Behold, the UNIVAC 1 in all its room-filling glory.

Noctua's air towers are some of the most advanced phase-change designs around.



fans on a tower, you have a radiator; rather than vapor or condensed liquid, you have coolant; and instead of convection, you have a pump. This gives you a larger thermal capacity overall, and increases your ability to cool components with a larger thermal footprint.

In fact, it works in a very similar way as the cooling system in a car's engine. A pump pushes coolant around (or anti-freeze, in the case of a vehicle); it then enters a water block, where it heats up, then moves on through a radiator, which has cooler air passing over it, thanks to a fan or two, which draws the heat out of the coolant, ready for it to begin the cycle again. The advantage is that the coolant typically has a far higher thermal capacity than the liquid in CPU fan towers, and there's a greater surface area for cooling the coolant, thanks to the radiator.

The Beginning

Liquid cooling has been around for almost as long as there have been computers in one form or another. In the '50s and early '60s, supercomputers such as the UNIVAC 1 and IBM's System 360 were making waves by dipping into the chilly stuff to keep their temperatures low and performance high. By the '80s, the majority of server mainframes and supercomputers were being liquid cooled. It was only in the mid '90s, however, that it began to take off in the world of personal computing,

with modders and overclockers reaching for the hand tools to build their own CPU water blocks from scratch to ramp up their performance. As always with overclocking, with more volts comes more heat. And thanks to everything from plumbing fittings to car parts, and homemade blocks to jerry-rigged radiators, the world of consumer liquid cooling came to be, and it wasn't long before companies such as XSPC, EKWB, and Alphacool began to capitalise on the market in the late 2000s.

Since then, designs have changed quite dramatically for blocks, parts, and components, but one thing that's stayed relatively stale over the years is the coolant, especially if you want ultimate performance. For the absolute elite, the be-all and end-all answer has always been distilled or deionised water. In its purest form, it was the most thermally efficient coolant out there, and readily available, too, at a super-low price. With a touch of biocide or a silver coil, it's fairly resistant to gunge and bacterial build-up, and with a splash of dye, you can even make it look quite pretty, albeit at the cost of performance.

As PC gaming developed, and the enthusiast community grew, with various YouTubers showcasing liquid cooling to the community, major brands such as Corsair, Thermaltake, and more have jumped on board with their own brands of bespoke custom liquid-cooled parts. And yet, coolant still hasn't advanced that much, certainly not when it comes to outperforming pure water. We've seen opaque coolants, such as Mayhems Pastel, and particulate coolants, perfect for photo shoots and show builds, plus various dyed coolants, but nothing has come close to beating H₂O.

Mayhems 6nm XTR

This is where XTR comes in. Its coolants are somewhat renowned for quality and performance the world over, and the firm has been in the industry for well over a decade, developing and working on a wide range of coolants for PCs. The small British company was the manufacturer behind some of EKWB's coolants until relatively recently, and now it produces all of Corsair's coolant for its custom liquid-cooled line, too.

That means it's got some serious clout and technological knowledge



The testing kit comes with four bottles of treated and untreated coolant.

behind it when it comes to the world of thermodynamics. When Mayhems' owner, Mike, reached out to APC, offering us the chance to test some of the company's XTR coolant, we could hardly refuse. "Why is that?" you might ask. Well, XTR is quite possibly the most advanced coolant we've ever seen. In fact, in testing, the current 6nm variant has been shown to outperform water by 9–10 C in some scenarios. That's a big difference in the context of cooling. What's more, XTR is entirely grown (yes, grown) in a lab, it doesn't contain any glycol whatsoever, and it's 100% synthetic.

Now, Mayhems is being very tight-lipped about the manufacturing process, for obvious reasons, but what we do know is that these 6nm particles are grown to size, and XTR is an industry first. No other company has managed to create a coolant that has such small particles on a mass scale, and managed to keep it suspended, as can be found with XTR. In fact, Mike explained to us that the aims of XTR were simple:

- To create a coolant that needs no biocide or other forms of active

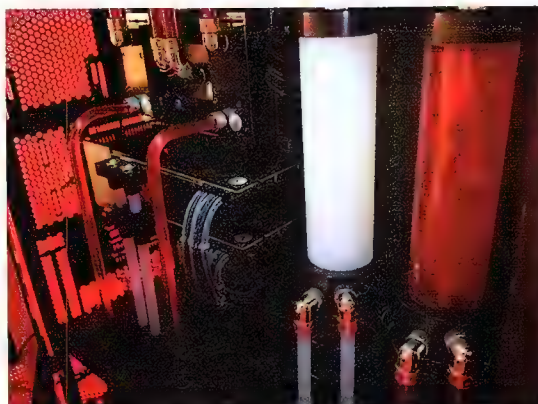
chemicals that die off over time.

- To have a 100% light-blocking capacity that lasts longer than 10 years.
- To absorb heat better than anything on the market.
- To be able to withstand temperatures that no other coolant is able to and still keep working.

All of these goals have been achieved according to both Mike's and multiple other beta testers' results. In fact, it's so effective that we've even seen video evidence of it absorbing and blocking a hit from a 6KW fiber laser dead in its tracks. And the way it behaves with RGB and LED lighting in a system really makes you realise just how special this stuff is – but more on that later.

It all sounds great, but we were a little apprehensive about giving it a try for a number of reasons. Firstly, this is the world's first 6nm particle coolant, so it does make us a little nervous when it comes to handling it. To give you some idea how small 6nm is, a red blood cell can be up to 7,000nm wide, a strand of DNA is around 2nm wide, and that nasty virus going around measures 100nm. So this is small, really small, which means there'll be plenty of rubber gloves involved. Secondly, it's expensive; we haven't been given an accurate figure as to how much it costs to produce, but it's currently listed on Mayhems' store page as US\$45 per liter. Ouch. And finally, we needed to find a decent system to convert into a test bed. However, with a bit of Dutch courage and some soothing words from Mike himself, we took on the challenge, and here's our first look at what it's like to be a beta tester in the world of the hyper-nano.

Liquid cooling is now commonplace.



Length of time: 2-3 hours | Level of difficulty: Complex

Reconfiguring the Pink PC

Our console-killer needs some love to get it ready for testing.

Our Pink Pariah has had its fair share of knocks and scrapes since we built it pre-lockdown, and it's in dire need of a renovation and some key component adjustments before we can inject any new coolant into the thing.

At its heart this machine has an AMD Ryzen 5 2600X six-core, 12-thread processor, an Asus ROG Strix GeForce RTX 2080 OC Edition graphics card, 16GB (2x 8GB) of Corsair Dominator Platinum RGB DDR4 @ 3,200MHz, and a 1TB WD Black PCIe 3.0 M.2 SSD with heatsink, all inside a Phanteks Evolv Shift X (sadly no longer for sale), and powered via a 750W Corsair SF750 80+ Platinum PSU.

Back in its heyday, it was no slouch in the performance department (especially for living-room gaming), but with the advent of the RTX 3000 series, Intel's 10 series CPUs, and AMD's Ryzen 3000 series, it's now somewhat long in the tooth. However, the thing it has always done really well is produce heat. And that's something we absolutely need to test out here. With the panels on and dust filters in place, this tiny system often hit 85 C on the GPU alone during long-term intense gaming sessions at 4K.

When this writer's future spouse got fed up of it being in the living room and told him to move it upstairs, we removed one of the rear glass panels and pulled off the dust filters from the sides with the radiators attached to improve airflow, and this dramatically



affected temperatures – under-load GPU temps topped out at a meager 59 C compared to that aforementioned 85 C, with CPU temps hitting 69 C max. Neat, and that’s just adjustments to intake air, plus space to exhaust that heat.

The Upgrades

So, what needs fixing? Well, the problems lie in both the usability of the machine for draining and filling, and some potential issues that may arise in the future in the form of the water blocks we originally attached to the CPU and GPU.

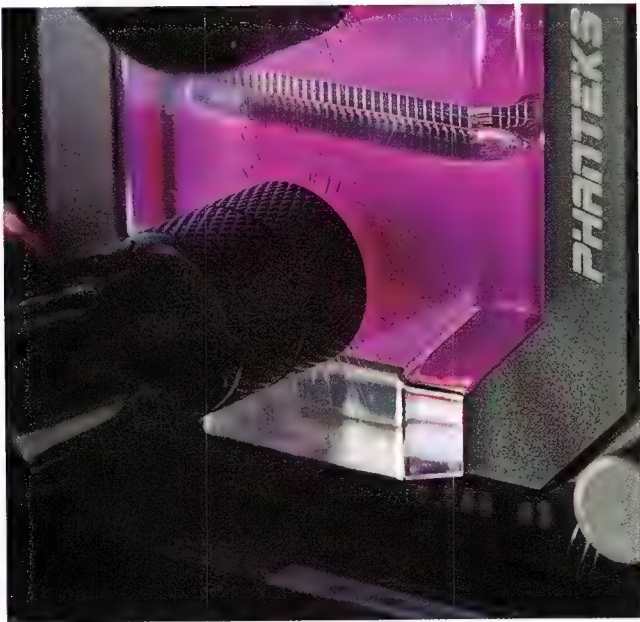
When we built it we decided to use Phanteks’ latest liquid-cooled water blocks. Everything else – frosted tubing, pump, reservoir, RGB rings, and radiators – came from Alphacool. For our coolant, we went with Mayhems’ Pink Pastel.

The problem is that the water blocks on the CPU and GPU have developed microfractures around the G1/4-inch ports. We think this is due to user error, because we used ethanol to clean the blocks during the original photo shoot. Using alcohol on plexi typically causes it to shrink, then develop microfractures. Over time, they can lead to full-blown leaks. Not good.

We also need to add a decent drain port at the bottom of the system, and preferably an aeration port at the top as well. For all of this we reached out to Alphacool to get some additional gear in to reconfigure the loop for our new tests. This included a new CPU block, a new GPU block, and a few new fittings to add an aeration valve. But that does mean we need to fully drain, strip, and reconfigure the system ready for the tests.

INGREDIENTS

PART		STREET PRICE
CPU BLOCK	1X ALPHACOOL EISBLOCK XPX CPU SATIN CLEAR	\$150
CPU LIGHTING	1X ALPHACOOL AURORA XPX DIGITAL RGB FRAME BLACK	\$25
GPU BLOCK	1X ALPHACOOL EISBLOCK GPX-N PLEXI LIGHT RTX 2080 SUPER M08	\$200
T-BLOCK FITTING	1X ALPHACOOL HF CONNECTION TERMINAL TEE G1/4 BLACK	\$25
M-M EXTENSION (SMALL)	1X ALPHACOOL EISZAPFEN DOUBLE NIPPLE G1/4 BLACK	\$12
M-M EXTENSION (TINY)	1X ALPHACOOL HF DOUBLE NIPPLE G1/4 BLACK	\$10
90-DEGREE EXTENSION	2X ALPHACOOL EISZAPFEN L-CONNECTOR G1/4 BLACK	\$24
DUAL 45 EXTENSION	2X ALPHACOOL EISZAPFEN ANGLED ADAPTOR G1/4 BLACK	\$20
M-F EXTENSION (SMALL)	1X ALPHACOOL EISZAPFEN EXTENSION G1/4 OUTER TO INNER BLACK	\$12
TUBING	1X ALPHACOOL EISROHR 13/10MM PLEXI HARDTUBE SATIN 80CM 4PCS	\$45
TOTAL		\$535



01 OF MICROFRACTURES AND MEN

Here we have a prime example of what we’re talking about with regard to those microfractures. These have been developing slowly over time on the block, ever since the photo shoot, progressively getting worse, but as this rig isn’t used often, they’ve not been at the top of our list of priorities. You can see the fractures are emanating from the G1/4-inch ports themselves – this is obviously where there’s a considerable amount of pressure being pushed down and where the plexi glass is weakest. Top tip: Don’t use alcohol wipes on your plexi blocks.



02 DRAIN PORT CANDIDATES

This is our first candidate for a drain port location. Thanks to the design of the Alphacool radiators, there are multiple G1/4-inch ports on both sides. This is the slim 120mm radiator we have in the “bottom” of our case, next to the PSU. The 120mm fan there effectively sits below the chassis, stuck between the case and its detachable feet. In a perfect world, we’d disassemble the entire machine, drill out the plate, and attach a 90-degree fitting and a ball valve. However, the radiator has an additional port, facing out on the other side, which could be a better solution, and it doesn’t require any modding. The only problem is that if a ball valve is used there, it will stick out the back of the case, and you won’t be able to reattach the side panel (or tempered glass window).



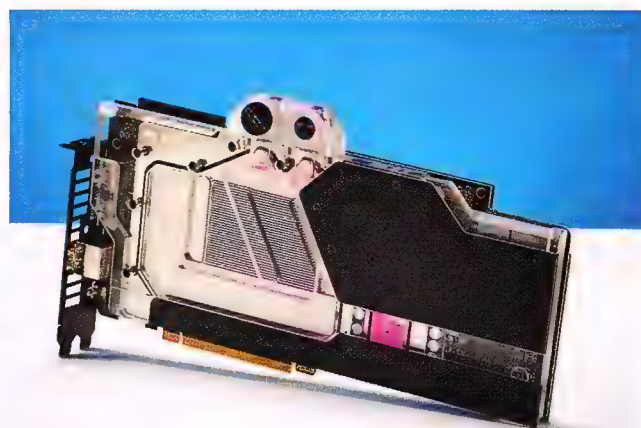
03 AERATION VALVE

One of the key principles involved when it comes to draining a liquid-cooled system is the movement of air and pressure. Gravity helps you move some fluid from a pressurised system, but if you don't have air passing through it, it's a very slow process. In systems with both a fill and a drain port, usual best practice is to open the drain port (draining the coolant out into a bucket), and open the fill port as well, so air passes through and the coolant flows out at a much faster rate. Because our system's fill port is located in the middle of our PC, this does present some issues when it comes to draining. So, we're adding an additional aeration valve (effectively a T-block fitting, with a plug on top of it) at the very top of our rig, to help the draining process.



05 BLOCK SWITCH

With the GPU out, we then turned to the CPU block, and removed that as well, being extra careful because the RGB cable plugs directly into the case itself. Here is where we made our first mistake, because we accidentally got some coolant on the board. We did the best we could, mopped it up with a microfiber cloth, then used a heatgun to dry the board off – however, this would come back to bite us later. Then we placed in the new Alphacool block (a satin block to match our tubing), and attached the DRGB frame as well, and plugged it into the header close by. After that, we were lucky, in that all the tubing runs we'd used in the previous build fitted perfectly back into position, with some help from a bit of flexibility from those angled fittings.



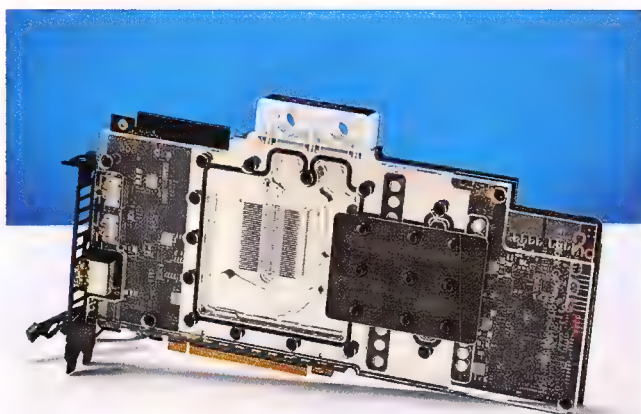
04 SYSTEM DRAINED

To drain our system, we moved to it a sink, carefully unplugged the bottom port on the radiator, and quickly attached a length of soft tubing, placing the end in the sink. Then we opened up the fill port on the reservoir and began to drain the coolant as best we could. As our fill port is in the middle of the loop, we attached a clean length of soft tube to it, then blew into it, to encourage the rest of the coolant to leave the system. Only do this if you're replacing your coolant with one that contains a biocide, because it can introduce bacteria to the system and encourage organic growth. Once as much of the coolant was out as possible, we started to disassemble the various parts of the machine, including the GPU. G1/4 ports on different manufacturers' blocks can be in different locations, so it's no guarantee that, when swapping blocks, the tubing will fit back in place afterward, but it's handy to keep them nonetheless.



06 T-BLOCK INSERTION

We then removed the topmost tubing run (now hanging loose since the removal of the GPU), and placed it to one side. With the 90-degree fitting out, we installed a small male-to-male extension, then screwed in a T-block – a giant extension fitting that has G1/4 threads at three locations. You can also get X-blocks and Y-blocks. They're usually designed for adding drain ports, or splitting flow off in parallel loop designs, where coolant flows through two separate runs at once. We're using it as a pseudo 90-degree fitting, then placing a plug on top to act as an aeration valve. There's a slight issue with the fact that it's not rotary, as once it's secured, that's the angle you get. Fortunately, the panel pass-through fitting it's attached to can rotate in the hole we originally cut out of the case, so it's not an issue. If you use one, pair it with a male-to-male rotary extender, to avoid the problem.



07 GPU BOO-BOO

We're never ashamed to admit when we mess up, and this was the second major boo-boo of the build (the first was getting coolant on the motherboard). In short, midway through the first day's photography and system stripdown, we realised we'd ordered the wrong GPU block for the graphics card. The Asus ROG Strix RTX 2080 OC uses a custom PCB, and we'd ordered in the block for the reference design instead. D'oh. A quick call to Alphacool, and it managed to ship us the correct part in less than a day. Fun fact: The expedited shipping almost cost more than the block itself. You can see the differences between the two GPU blocks: The one installed, the M08, is far larger than the one we originally requested (M02), and comes with a cut-out for those MOSFETs that the other doesn't have. You win some, you lose some.



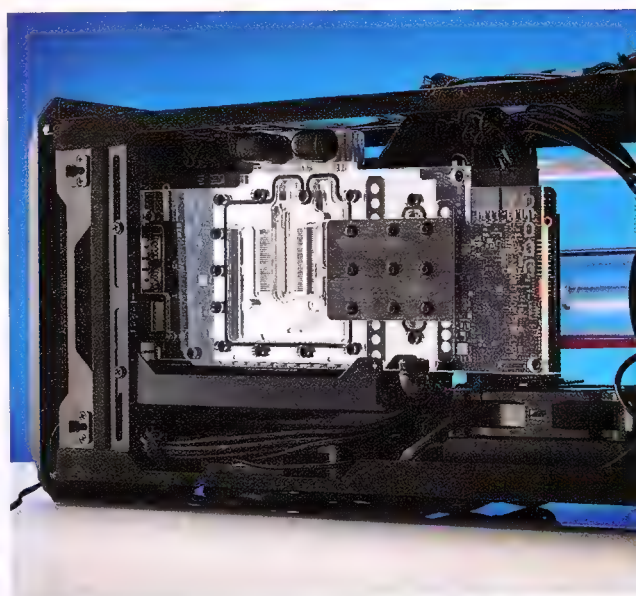
09 WAIT! THERE'S A PROBLEM

With the old GPU block, we used the backplate that came with the standard air cooler. This retained the RGB lighting and kept the card quite slim. However, with the Alphacool block, you have no choice but to install the backplate that comes with the card. The problem is that it extends the GPU block out back, as it has thick thermal pads to help dissipate heat from the back of the memory chips and other VRM parts. This would be fine in any other build, but our reservoir is in a fixed location and can't be moved. Basically, the GPU wouldn't fit back in its slot at all. To get around this, we took inspiration from last issue's Hydra Mini build, and unsecured the PCIe riser cable that comes with the Shift X, attached it to the card pre-installation, then secured the card in place at the back, so it can rest on the reservoir without contacting anything or creating any conflicts. Annoying? Very.



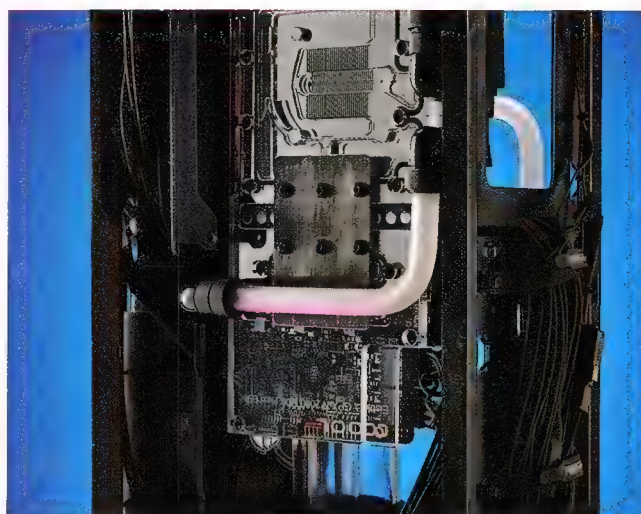
08 GPU BLOCKS

We've finally got the correct water block in, so it's time to install it on the card. How do you go about that? Well, the first thing we had to do was remove the old Phanteks block. We've got the entire card removed from the case and plugged up, so next on the list of things to do is remove as many screws as we can. Remove the backplate first, and that gives you access to the main screws that hold the GPU block in place. Once that's out of the way, it's time to carefully remove the card from the block, then proceed with a quick clean-up and removal of the old thermal paste and thermal pads. After that, installing the Alphacool card is a piece of cake. Use the included colour-coded thermal pads in the positions indicated by the manual, add a blob of thermal paste to the GPU, then carefully pop your graphics card on to the water block, lining everything up. Add the remaining pads to the backplate, screw it down, and you're good to go.



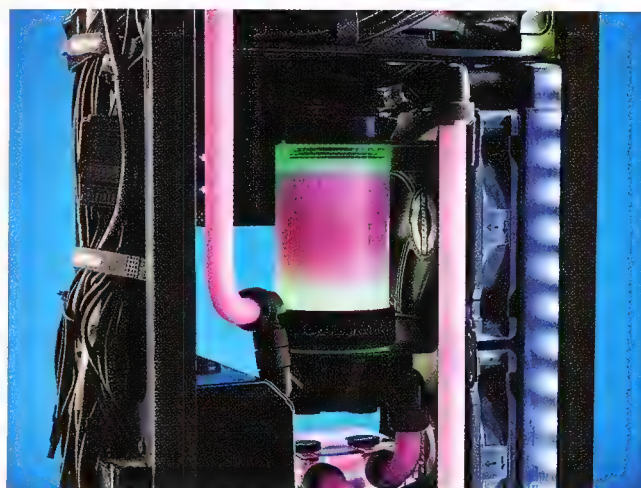
10 GRAPHICAL ALIGNMENT

At last, we have the GPU in position - it was a bit of a squash and a squeeze, but it's in now and not touching anything. We've also extended the fittings on the front radiator to give us a little extra room, and that tubing run that goes from the front radiator to the graphics card is going to be redone as well (the original setup had a slight crookedness to it that annoyed us). There's a little wiggle here now, but we're not too worried about it, because once the tubing runs are all in place, and the fittings secured, that should help keep it in its position. It's still got the two PCIe notches in place as well, and the screws above it, too, so it's not all that bad.



11 MISSTEPS AND ADJUSTMENTS

Look at that pink coolant in the bottom tube. This is a fresh tube that we've just bent and installed, and used an extension fitting to get to sit right, and it's got coolant in it. Where from? The radiator. It's all too easy to fail to properly clean coolant out of a system. In this case, though, it's intentional, as Mayhems requested that we test the coolant under all sorts of conditions: With a flushed loop, with gunk in the system, with some coolant still in there – the idea is we look for any user scenario and see how the coolant responds. The second thing to note is we've got away with reusing the same tubing that connects the GPU to the T-block. The only thing we needed to do was shorten one end and add an extension fitting to the other. The angles are very precise, and it would have been a nightmare to bend a fresh tube.



13 ODD COOLANT

With the system primed, we notice that it's a lot pinker than we thought it would be. This is no doubt in part to that pink pastel coolant being trapped in the radiators from before – ideally, the whole system would need a few flushes to get the bulk of the coolant out, but we sadly didn't have time during the shoot (a proper flush requires the loop to be running for a good 24 hours). Nonetheless, the way this coolant reacts with light is something else. As you can see, the light ring we attached to the reservoir emits a green glow, and the coolant immediately around that absorbs it and changes colour, while it's a lighter pink in the rest of the system. Change it to any other colour and you see the same result. In fact, you can see this even better in our frosted CPU block, up top, in the next shot. It seems the particles themselves reflect the light wavelengths – brilliantly so.



12 TIME FOR SOME MAYHEM

As this coolant is different from most, and the size of the particles in it are smaller than blood cells, we've taken some extra precautions. Equipping ourselves with a decent pair of latex gloves, we carefully pour the XTR coolant into our fill bottle over a sink, secure the cap on the bottle, and head back to the machine. We remove the plug from the 90-degree fitting on top of our reservoir, and remove one of the plugs from the top of the res (to act as our fill port). We add a length of clean soft tubing to the 90-degree fitting. This is going to be used as a last resort to move the coolant around the loop if necessary by blowing into it. According to Mayhems, XTR is very effective at killing off any potential bacterial growth. Then it's a case of filling the reservoir, sealing the caps, and powering the pump off a separate power supply to cycle the coolant around the system.

14 OFF-CAMERA PROBLEMS

We mentioned we made two major errors during the conversion process for this rig. The first was requesting the wrong GPU block; the second was that we got coolant on the motherboard. A quick glance at this picture and you'll notice that the Corsair Dominator Platinum memory is cycling through its RGB rainbow preset, in a similar manner to the CPU block (the reservoir light is controlled via a small in-line remote). At the time of the shoot, we believed that small spillage on the board had managed to get some particulate into some of the memory traces and was causing the board to short, stopping us from configuring it. We left it for a couple of days extra after the shoot to try to let it dry out further, but to no avail. On a hunch, over the course of a weekend, we drained the system entirely, and disassembled the top part of the build, near the motherboard, to take another look. After reseating the CPU and memory, then refilling the system with one of our other bottles of coolant, lo and behold, the system powered on and displayed properly.



Conversion complete

The problem with this type of build is that reseating the CPU to troubleshoot a problem involves draining the rig entirely of – in this case, particularly expensive 6nm – coolant, cleaning out as much as you can, getting enough microfiber cloths and paper towels together, then disassembling the entire top half of the loop just to get to the processor. Then you have to reassemble it all, refill it, and see if it works. If this is your only system, it's an absolute nightmare.

The reality is, although it was an interesting challenge to convert this build, it's not a very practical system. Swapping out blocks and coolant at the same time led to problems. What we should have done was swap the blocks earlier on, tested it again, long before the photography dates, drained it after we knew it was all working, then filled it again with the XTR coolant for our experimentation.

To be really thorough, it would have been better to have gone for a far simpler system. The Shift X is an interesting chassis, and to liquid-cool in it is as challenging as builds like this go, but it's not very representative of a normal liquid-cooled system, nor is it particularly easy to maintain, drain, or even move around.

The results

So, how much difference did XTR make? There was a significant improvement, but not as much as we've seen from others who've used it. Performance was solid across the board – temperatures dropped significantly, in some cases by up to 6 C compared to the pastel coolant. That's not quite as high as we've seen some beta testers get (there have been reports of a 9–10 C drop compared to deionised water), but we have some theories as to why our results might be lower.

The biggest difference we saw was when we were using the Shift X build with the rear glass panel and dust filters in place. This is our sort of baseline test, for what this system ought to look like, and where it gets hottest. In this setup, the temperature drop across the GPU and CPU varied 4–6 C from test to test. Just for a pure coolant swap, that's pretty solid. However, remove the glass panel and dust filters, and the difference falls to about 2–3 C. Still an improvement on what we had previously, but not quite as dramatic.

We have a hypothesis as to why this is the case. Firstly, the system isn't fully flushed. There's still a lot of the old pastel pink sitting in the loop. That coolant had been in there for almost a year when we drained it, so it wasn't exactly fresh, and

that means the XTR coolant is effectively diluted. That's a problem on our part.

Secondly, we believe a lot of XTR's performance depends on the maximum thermal capacity of the loop. With liquid cooling, we recommend that you have a minimum of 120mm of radiator surface area per component you want to cool; double that if overclocking. Combine that with fans, airflow, internal air setup, pump speed, and reservoir capacity, and you end up with the loop's maximum thermal capacity. Removing our rear glass panel and dust filters dropped temperatures dramatically compared to if we ran with the case sealed. This suggests that our positive pressure setup with the Phanteks fans doesn't exhaust heat fast enough. Take the side panel off, and all that heat can escape, as the positive pressure from the intake fans pushes it out – all of a sudden, temperatures drop significantly.

The theory is that XTR is far more efficient at transferring heat into the radiators than standard coolant. When you're at your thermal limit within a loop, the best thing you can do is move heat to a radiator as fast as possible, then transfer it into the fins to be expelled or cooled by the fans. With our panel off, the internal temps were far lower naturally, thanks to that release of internal hot air. With the panel on and internal temps far higher, XTR moves heat away from the blocks and into the radiators at a far quicker pace than a standard coolant, so we see a bigger drop in temperature.

That means if you're looking to cool a 12-core processor and an RTX 2080 Ti off of a single 240mm skinny radiator, XTR should far outperform a standard coolant, or even water, because at that level, the temps should be much higher and the coolant should perform much better.

On to the next tests

We're not satisfied with our results just yet; we want to see how it responds when the system's flushed fully, and is free of pastel residue. To that end, we're going to blitz the system and crack open another bottle of the white stuff, and see how this coolant performs over long periods under load. Rumour has it that it improves with age, and temps drop further the longer it's in a system, so we'll have to check that out, too. We also want to build the "Impossible Machine": An ITX chassis, a single skinny 240mm radiator, a tiny pump and reservoir, a 16-core processor (if not more), and the best/hottest GPU we can get our hands on. It will take a while to get the parts together, but once done, it should prove once and for all whether Mayhems' XTR is truly the king of coolants. ■

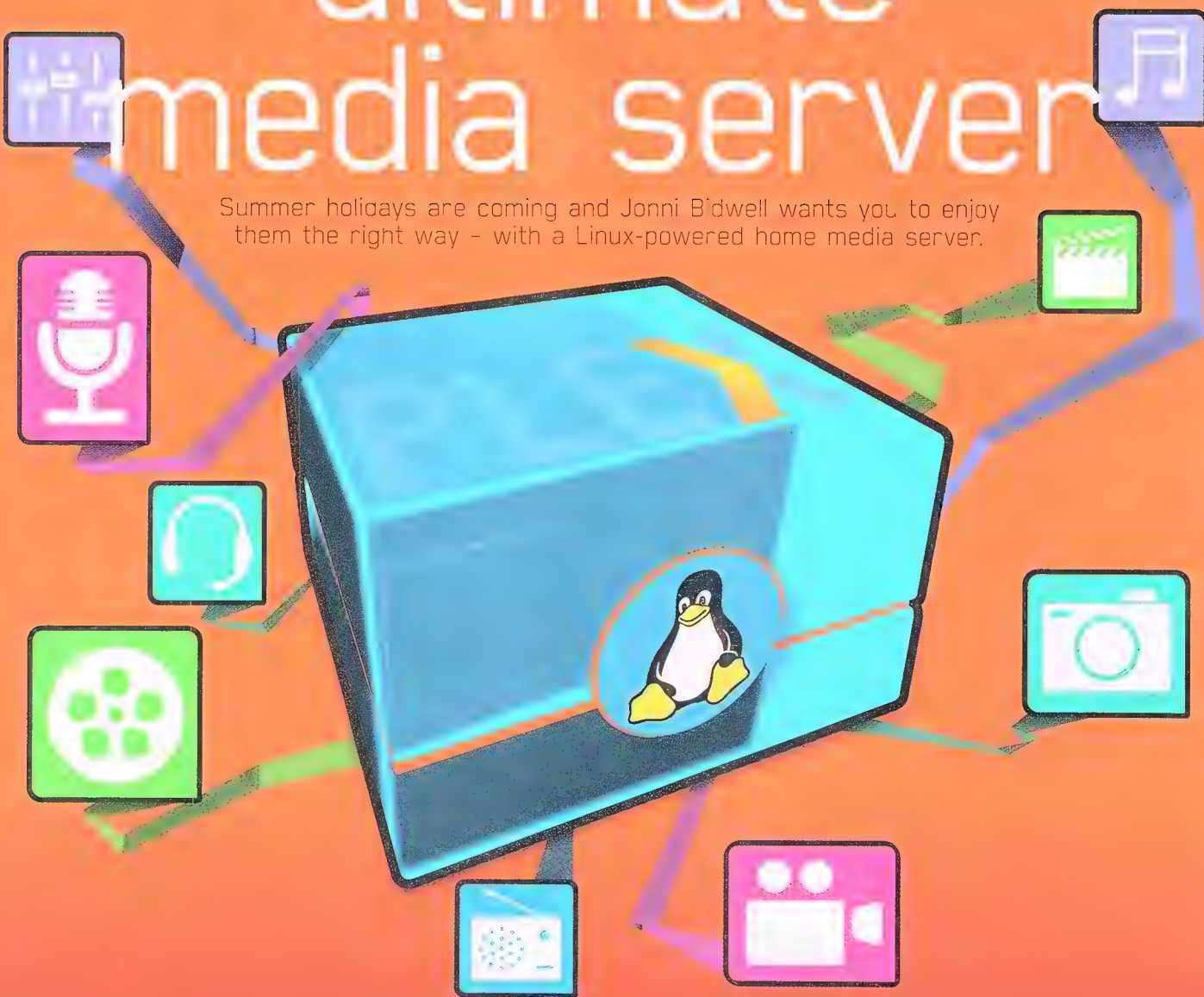
	Mayhems Pastel – panels off		Mayhems 6nm XTR – panels off	
Idle CPU temperature	38		37	
Idle GPU temperature	31		32	
Prime95 blends test	69	36	66	35
Cinebench R20	66	35	64	35
3DMark: Fire Strike	74	61	71	58
TechARP x264	69	39	66	36
Assassin's Creed Odyssey	62	67	60	64

	Mayhems Pastel – panels on		Mayhems 6nm XTR – panels on	
Idle CPU temperature	39		37	
Idle GPU temperature	32		33	
Prime95 blends test	78	41	73	37
Cinebench R20	76	39	70	38
3DMark: Fire Strike	81	75	76	71
TechARP x264	80	44	76	41
Assassin's Creed Odyssey	75	79	71	74

Best scores are red. CPU temp left, GPU temp right. All figures are degrees Celsius. 3DMark and Prime95 ran for an hour before the highest figure was noted. TechARP x264, Cinebench R20, and Assassin's Creed had three consecutive benchmarks run before final temperature noted. Temperatures monitored with HWMonitor. Assassin's Creed: Odyssey was tested on the highest preset at 4K. Local ambient temperature registered at 22 C, with humidity at 62%. Cool-down period was 30 minutes between tests, and fans were set to a fixed RPM of 50%. Aside from the XMP memory profile, there was no overclocking outside of stock parameters. Our test system consists of an AMD Ryzen 5 2600X, Asus ROG Strix GeForce RTX 2080 OC, 16GB (2x 8GB) Corsair Dominator Platinum RGB DDR4 @ 3,200MHz, a 1TB WD Black SN750 M.2 PCIe 3.0 SSD, and an Asus ROG Strix X470-I Gaming motherboard powered by a Corsair SF750 80+ PSU. Intake fans are 3x Phanteks PH-120MP PWMs, exhaust fan is 1x Phanteks PH-F140MP PWM.

Build the ultimate media server

Summer holidays are coming and Jonni Bidwell wants you to enjoy them the right way – with a Linux-powered home media server.



Summer is upon us and all kind of creatures and forces are at work. The veil between the worlds is thin, and on a warm moonlit eve you might hear the call of the Old Ones. Or perhaps that's the appeals of your long-neglected media collection, urging you to pay it some attention on these balmy nights.

Either way, hunker down as we show you how to set up a top-class media server with Plex and Linux. You'll be streaming your media all around the house in no time. With very little effort Plex gives you a Netflix-like interface for

navigating your movie, TV show and music collection. If you have a TV tuner, then Plex can use that too. If you already have a NAS device, then you can probably install Plex on it. We'll look at doing so, both traditionally and the new-fangled way with Docker.

And if you care for music more than you do for films we'll look at Airsonic. Install it at home or in the cloud, throw your music collection at it and you can stream your music anywhere in the world. Only a web browser is required to listen, and Airsonic is completely open

source. It's related to Subsonic and Madsonic, which you may have heard of, and mobile apps compatible with those sonic siblings can be used with Airsonic too.

We've also got some advice on hardware, and guidance on some other software that's worthy of your attention. So never mind the ghosts and ghouls – in fact, they probably want to join you for a scary movie night. Invite them over. What's the worst that could happen...

Take back your media

Don't be perplexed. We've got the lowdown on Plex right here!

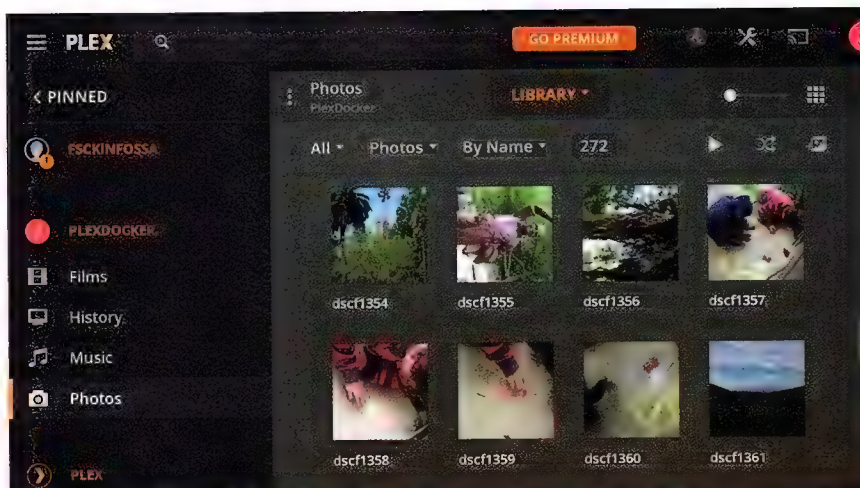
Streaming services have kept a lot of us sane over the past few months. The erstwhile occupants of APC Towers have put in a whole lot of hours binge-watching *The Boys* on Amazon Prime, smashing *Cobra Kai* on Netflix and watching endless hours of chess commentary on YouTube. Of course, we're fans of less proprietary options too, such as the decentralised PeerTube and the plethora of content available through the likes of Wikimedia Commons and Open Culture. However, as seasoned readers will be well aware, we're big fans of using Linux to self-host our own takes of these services.

And now is a great time to reacquaint yourself with your own media collection. Remember all those conspiracy documentaries that you downloaded in the mid-2000s? Or all those albums you dutifully ripped to OGG or FLAC files? Whatever your taste in media, chances are if you're reading this feature then you've got several gigabytes, and potentially hours of entertainment stashed away. And we're here to help you enjoy it. Whether you're at home, in the garden, or out and about.

Easy-peasy streaming

Over the page we'll show you how easy it is to install the Plex Media Server and stream your media anywhere. Let's be clear about this: Plex is proprietary software. We're covering it here because it has always supported Linux, is a fine choice for a media server and is extremely popular. There are plenty of other open source options and we'll look at some of those later.

If you want to support the Plex team, or have access to high-quality steaming media (and some extra features), then you can pay for a premium Plex Pass. Having a free Plex account enables you to



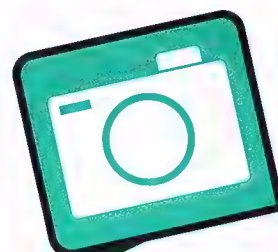
Plex can handle not only movies and music, but photos too. Which means our rights department don't get worried about copyrighted thumbnails.

"Plex is proprietary software. There are plenty of other open source options and we'll look at some of those later."

view Plex's own streaming channels (now available in over 200 countries), but these are funded by Ad-supported Video on Demand (AVOD). You may not be interested in Plex's premium features, and that's fine. However, if you are then check the box overleaf to see what your money gets you.

You can also use Plex without an account (free or premium), which is good news if you're against the idea of signing up to a third-party service at all. You might also prefer to skip to the end of the feature where we look at Emby (now also proprietary) and Subsonic. It's worth noting that you can associate your server with your Plex account, so having one

gives you a free authentication mechanism as well, although we'll show you how to lock things down properly for remote access later on, too.



Hardware considerations

If you're a beginner and want then your media files to get stored in some kind of file server. Perhaps you've followed a many storage-related tutorials and have everything nicely arranged on a RAID array in a box under the stairs.

This is fine, but a general purpose file server sharing files over Samba (the best choice for a heterogeneous network) isn't a particularly good job of streaming files to lots of users. It's not what the protocol was designed for. If it was, the few a couple of users over a gigabit ethernet, but accessing it remotely will be painful, especially as you start streaming through the fire.

Furthermore, some video players can cache backlogs of data from the opening network drive, and often end up copying

the whole file locally before playback is initiated. And that's just streaming.

Media streaming protocols are a much better job of getting the right data and bytes to clients as swiftly as possible. And since not all clients are the same, a big part of a media server's job is transposing, transforming one format to another.

There's a good reason why 4K video isn't your friend if you're a beginner. Transcoding requires CPU power, and your modern chips will happily transcode several streams at once, on the fly. Unfortunately it's not something that a Raspberry Pi will be able to keep up with.

Getting Plex installed...

Get your media server running in three steps, then fill it with media booty!

Plex can be installed on all kinds of devices – Linux, Mac and Windows machines as well as various NAS boxes (consumer devices as well as homespun efforts using tools such as FreeNAS and unRAID). The download page at www.plex.tv/en-gb/media-server-downloads provides DEB and RPM packages, and there's an official Docker image too (which we'll look at later at running via OpenMediaVault). The simple walkthrough below will get you started on Ubuntu, and the idea is the same for Fedora. There's an unofficial AUR package for Arch-based distros too. It's worth turning remote access off when prompted by the setup wizard. You can always turn it on again later.

In addition, if the automatic port forwarding works out of the box there's a chance your Plex instance could be co-opted by someone else.

To avoid painful rescanning later, we'd recommend taking some time now to ensure your media directories are organised. Plex works with libraries, where each library indexes media from one or more physical directories. To start with, you might have Music, Film and

Television libraries, and these types of media should all live in separate directories, and have their own heirarchy beneath them.

Plex can handle a number of different file naming and placing schemes, as long as they're consistent. For best results TV shows should have each season in a separate directory, for example TV/my.favourite.show/season.01/show.s01e01.mkv. Individual films can exist in their own directory – which keeps things tidy if they're divided into parts or have extra resources such as subtitles or artwork, just ensure the Local Media Assets source is selected in the Agents section in Settings to use these – or not if they're just single files. Plex recommends music directories be sorted by Artist and then Album, and named with the track number and title, for example Music/The Lemonheads/Come on Feel the Lemonheads/04 – Down about it.flac. Compilations should be placed in a Various Artists folder and each track should have the Album Artist ID3 tag set likewise.

There is some degree of flexibility though, so if you have a different (and

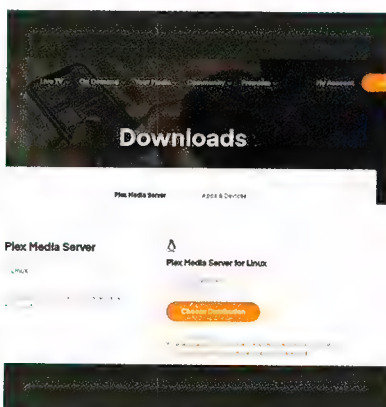
mostly sane) scheme in place then Plex will probably manage fine. We let it chew through a couple of terabytes of our media collection (not all of which had complete or accurate tags, and some of it was encoded many years ago in all kinds of peculiar approximations of various multimedia formats) sorted by genre and album, and it coped admirably.

Organise your libraries

To add a library log in to your Plex server (same address as step two below) go to Settings (in the top-right) > Manage > Libraries and select Add Library. If, for example, you've categorised your TV Shows by genre, and have a structure like TV/Documentary/History, then you should add each deepest subcategory (for example, History) as its own library, otherwise you might end up with a bit of a mess. Once they're scanned, new libraries will appear in Plex's sidebar. Click More to find them listed under your server name, with Plex's own offerings below.

By default, only their Home and Movies & Shows screens are pinned to the sidebar, so you'll also want to pin

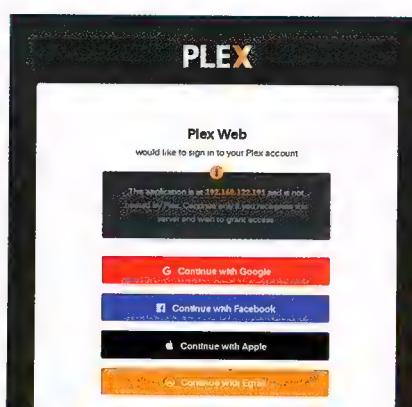
HOW TO Install Plex



01 DOWNLOAD AND INSTALL

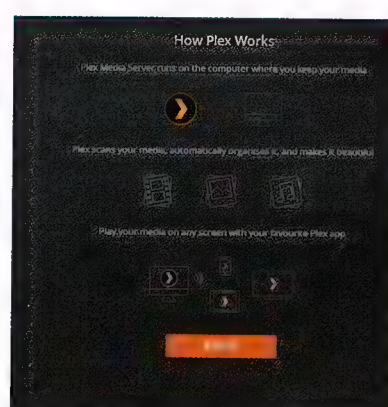
If you're using a desktop Ubuntu you can grab the DEB file directly from the Plex downloads page. Otherwise you'll want to copy and paste the link from there (because it's lengthy and ever-changing) to an SSH session on your soon-to-be media box:

```
$ wget https://downloads.plex.tv/plex-media-server-new.../plexmediaserver..._amd64.deb
$ sudo dpkg -i plexmediaserver_1.20..._amd64.deb
```



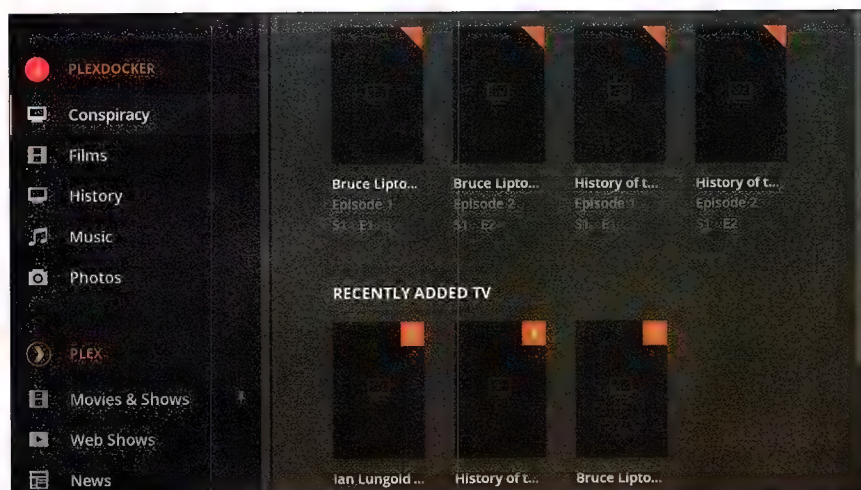
02 SIGN IN

Plex Media Server will start automatically, and you'll find the initial set up page at <http://<your server ip address>:32400/web>, replacing the IP address with that of your server. Sign in with your Plex account, or if you really don't want sign up you can skip by clicking "What's this?" and accepting limited functionality.



03 SCAN MEDIA

Click through the various welcome screens. You'll be asked to name your server and whether you want to enable remote access. Then you can add Film, TV and Music libraries to Plex and populate them with directories on your server. Before you do this, it's wise to follow the guidance on this page about how these should be structured.



Plex couldn't find thumbnails for our huge conspiracy documentary collection. Open your eyes, sheeple.

"Plex will use services like IMDB, (the imaginatively titled and open source) The Movie Database and Last.fm to obtain film posters and album artwork."

your new libraries there for easier access. You'll find that option by clicking the three dots next to each library. By default, Plex will use services like IMDB, (the imaginatively titled and open source) The Movie Database and Last.fm to obtain film posters and album artwork. You can configure other services, and your order of preference, in the Agents area in Plex's settings.

You've probably noticed the banner alerting you to an "unclaimed Plex server" on your network. Despite signing in to said server with your Plex account to set it up, your account isn't yet tied to your server, so claim it now by clicking the link just in case anyone else on your network does so. Once that's done, signing in with a different account won't offer access to the server. That user will instead be taken to their www.plex.tv homepage. This is why we didn't allow remote access earlier, it's now safe to do so and we'll look at that in a moment.

Configure Plex

With everything now pretty much set up, we should dig into Plex's settings a little. In Settings>Library you'll find options to automatically scan an entire library when changes are detected, or just the directory in which those changes took place. There's a separate setting for Music directories, because scanning a huge library with tens of thousands of files will may run you into the kernel's limit on the number of files that can be opened at a given time. All things being equal Plex will, unless told otherwise, stream the original media file to

whatever device the host is watching on.

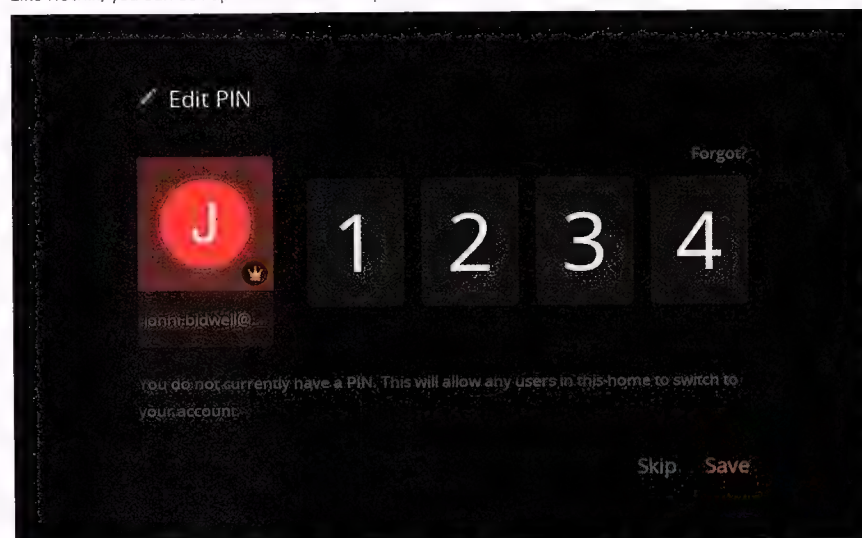
This may be undesirable, for example, streaming a 4K file to an old PC, so you can have the server transcode media on the fly during playback. Just hit the Settings button and adjust the quality dropdown. Files can be transcoded to x264 at fractions of the original bandwidth, down to sub 0.5mbit/s. Extensive transcoding operations running in parallel will take their toll on your server, so if you anticipate your machine being challenged then tweak the Transcoder options in the main settings page. Conversely, if your machine is fast you may want to turn everything up to 11. It's also possible to

generate bespoke versions of files in your library, saving the need for future transcoding. Mobile and TV presets are available, or you can choose a custom resolution, bitrate and platform. Click the three dots on a file's thumbnail and choose Optimise to generate these. You can keep track of your new files in Settings>Manage>Optimised Versions.

By this point, you should be able to access your Plex server from anywhere on your local network. If you grab the iOS or Android apps you can use your phone too (although to stream for more than one minute requires a Plex Pass). And there are apps for Sonos, Kodi, Roku and all manner of other devices. You'll still need to log in with your Plex account to see your media. However, you can share your libraries with other Plex users, or indeed add managed users (like Profiles in Netflix). Go to the Users and Sharing option in Settings. If your friends are too lazy to sign up for a Plex account, you can always sign up for them using a throwaway email address. You can even accept the invitation for them by copying the link after clicking Add a Friend. Adding extra users to the server itself is reserved for Plex Pass holders only.

Before you or your friends can access your server remotely, you'll need to enable remote access in the Settings menu. Plex will try and use UPnP to configure your router to forward a random port, but if this doesn't work it will tell you. You can try specifying a port in case this makes any difference. If not, you'll have to set this up on your router manually. This involves forwarding a TCP port (use 32400 if you're unimaginative, and don't mind being automatically scanned once in a while) to your server's IP address on the LAN, where Plex is running on port 32400.

Like Netflix, you can set up other users and protect access with a secure PIN.



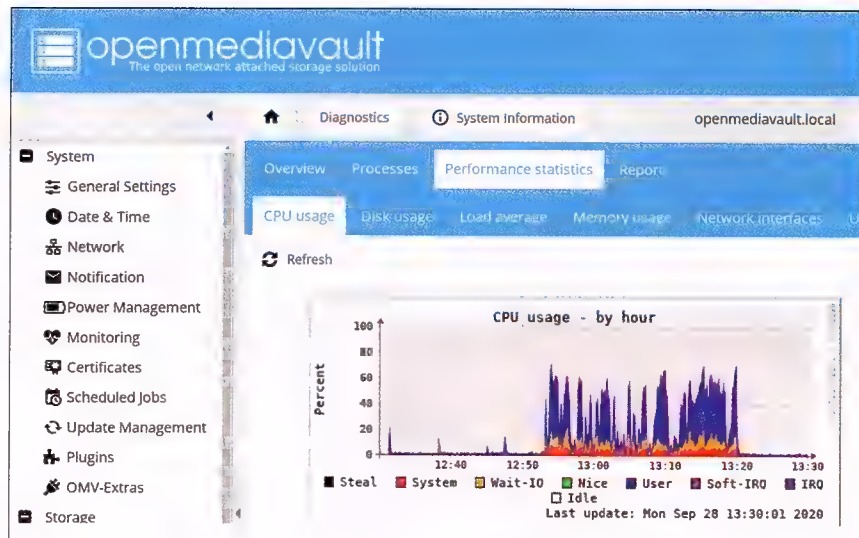
Make the most of Plex

Run Plex on your NAS, on Docker... anywhere! Plus a quick look at Jellyfin.

As has become fashionable in recent years, you can also use Docker to install Plex. Or if like us you've fallen for the Portainer web management interface for Docker, you can use that. Many NAS OSes make it possible for you to install Docker images too, including OpenMediaVault (OMV). There used to be a Plex plugin for OMV, but that's sadly no more, so onwards with Docker and Portainer!

The idea is the same if you're running Docker directly or through another NAS system, but do check the documents at <https://github.com/plexinc/pms-docker> for more details. You can, for example, skip having to claim the Plex instance using the PLEX_CLAIM environment variable. In addition, if you're fed up with manually having to start Plex from Portainer, change the Restart Policy to 'Always' after following the three-step guide below. An alternative image is available from linuxserver.io, which you may want to read more about from <https://linuxserver.io>.

Plex uses its own bundle of codecs (via the multimedia libavcodec library) so you should be able to play pretty much any (sanely encoded) file that you can throw at it. Hardware-accelerated transcoding is available to Plex Pass subscribers, provided you have compatible hardware. The docs recommend at least a fifth-generation



The Docker-ised Plex install on our modestly specced OMV box scanned 70GB of music library in half an hour.

Intel Core (although chips as old as the 2011 Sandy Bridge are supported) to use VA-API acceleration. AMD hardware should work with this too via the open source AMDGPU driver, and Nvidia's proprietary NVEnc API is also supported. The corresponding NVDec decoder is only supported on Windows. The client apps and web player will use whatever hardware is available. You can see how much work your server is doing either the old-fashioned way by logging in and using top, or by paying for a Plex Pass to

view some dashboard analytics.

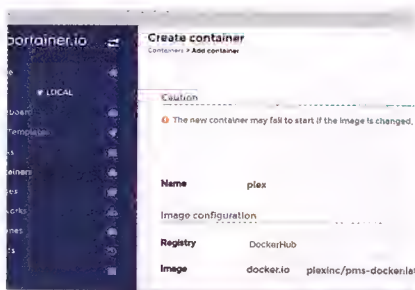
Speaking of analytics, if you have a lot of people using your server then you can use the third-party Tautulli application to see who's watching what. Tautulli used to be a Plex plugin, but the plugin management interface was disbanded by Plex in 2018. Besides movies and music, Plex can also look after your photos. This is a great way to share them with friends, and also rediscover old memories. Plex can edit metadata and make use of geotags to help keep them organised,

HOW TO Plex on Docker on OpenMediaVault



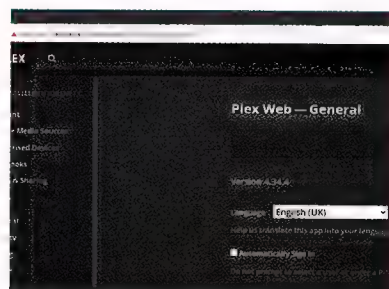
01 ANY PORTAINER IN A STORM

Log into OMV and set up the OMV-Extras repo. Next, go to System>OMV Extras>Docker and install Docker and Portainer. Open the Portainer interface by clicking Open Web (note that it runs on port 9000 of your server) and set up an admin password. Finally, log out and log in with this, and choose the Local endpoint.



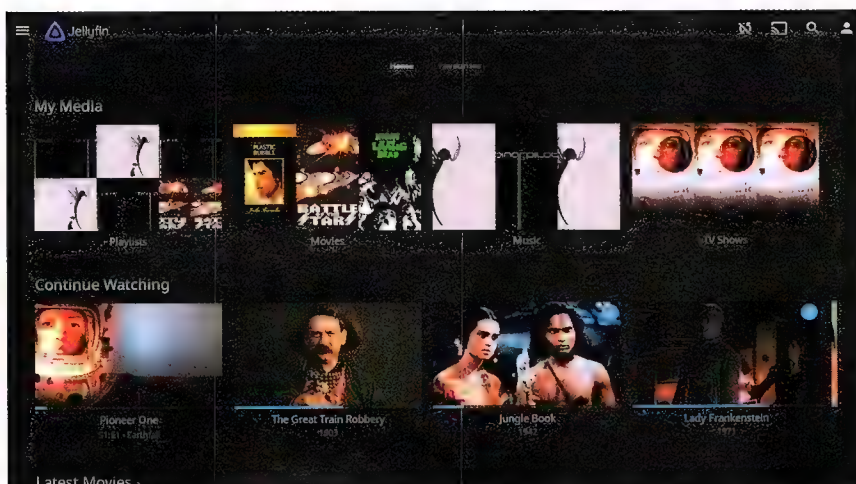
02 MOUNT AND CONTAIN

In the Containers section, choose Add container and enter `plexinc/pms-docker` in the image box. Before we fire up the image, we need to point it to our media collection, which we'll set up in the Volumes section by mapping `/data` as a Bind mount to, for example, `/srv/dev-disk-by-label-RAID`. Check the docs for networking options.



03 DEPLOY AND ENJOY

Deploy the container and Plex should be available at <http://your-ip:32400/web>. The setup process is exactly as on the previous pages, only you'll find your media in the `/data` directory on the container. You can also bind mount the `/transcode` and `/library` directories, which would make for a more portable installation.



Try out the Jellyfin demo to enjoy some freely licenced media and see how it compares to Plex.

"Plex uses its own bundle of codecs so you should be able to play pretty much any (sanely encoded) file that you can throw at it."

too. And of course, it can render endlessly repeating slideshows to entertain your guests at dinner parties.

Beyond Plex

There are of, course, other media streaming options besides Plex. One of the most popular is Emby, which started life as Media Browser (see, 'MB', geddit?). At one stage Emby was open source, then a few components became proprietary, and as of 2018 it's now closed source. Like Plex, a premium option (Emby Premiere) is available that

offers additional features. However, unlike Plex this doesn't provide you with any content. You'll find the latest releases (currently 4.4.3) at <https://emby.media/linux-server.html> and a beta 4.5 series release is also available. The installation process is much the same as Plex, although a Flatpak is available if you'd rather do things that way.

For a truly open source media server, we'd direct you to Jellyfin. It's a fork of Emby and as you can imagine apps are available for mobile devices, as well as Kodi, Google Cast, AirPlay and more.

Docker images are also available – the official one ([jellyfin/jellyfin](https://hub.docker.com/r/jellyfin/jellyfin) on Docker hub) uses a Debian base, but linuxserver.io and [hotio](https://hotio.com) provide Ubuntu based images. There's nothing to stop you (if you followed the Portainer/Docker install section earlier) from adding the Jellyfin image and bindmounting it to the same media directory. This will enable you to do a side-by-side comparison of each tool.

To install Jellyfin on Ubuntu server (you'll probably have the two packages below on desktop already) start by adding HTTPS transport for Apt and enabling the Universe repository (needed for FFMPEG dependencies):

```
$ sudo apt install apt-transport-https
```

```
$ sudo add-apt-repository universe
```

Next, add the Jellyfin signing key to the Apt keyring:

```
$ wget -O - https://repo.jellyfin.org/ubuntu/jellyfin_team.gpg.key | sudo apt-key add -
```

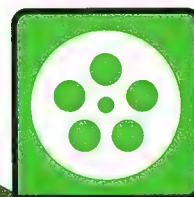
Now add the repository with (change Focal and amd64 if you're on a different release or architecture):

```
$ echo "deb [arch=amd64] https://repo.jellyfin.org/ubuntu focal main | sudo tee /etc/apt/sources.list.d/jellyfin.list
```

And finally update the repos and install Jellyfin:

```
$ sudo apt update
```

```
$ sudo apt install jellyfin
```



What are the benefits of a Plex Pass?

In July Plex announced over 80 channels of Live TV being made available to Pass holders. If you have a TV Tuner, then Plex Pass will enable you to stream and record local TV directly from it. If you use the Tidal music service, then you can connect Plex to that. Even if you're just using Plex for local media, having a Plex Pass enables it to download trailers and artwork from sources such as IMDb.

Pay for a premium Pass and extra features include offline media syncing for mobile devices, a server dashboard and 4K support. You also get hardware transcoding, which leverages the power of your GPU to stream to more users at higher resolutions. If you have a modern, multi-core CPU you'll still be able to handle a few users at 1080p without this feature, but it's nice to give your processor a break. A Plex Pass subscription also gives you access to parental controls, as well as more advanced sharing and bandwidth management options.

Plex Pass

Enhance your Plex experience with exclusive premium features



Mobile Sync

Enjoy your media offline on Android and iOS devices



Live TV & DVR

Connect a tuner and antenna to record free QTA broadcasts



Parental Controls

Set up managed user accounts to create custom access restrictions



Webhooks

Connect your media server to your home automation system



Server Dashboard

See the play history, bandwidth, and log users on your media server



Premium Music Magic

Sweet Fades, Loudness Leveling, Lyncr, and more

...plus more exclusive features!

Recently Plex Pass holders got yet another new feature: the ability to skip intros.

Run an audio server

If music be the food of love then stop waffling and set up a simple music server that will keep you nourished wherever you are.

Back in 2018 Google announced it would be shutting its Google Play Music service, which gave you free storage for up to 50,000 music files. Combined with its web app for streaming them to wherever you are in the world, this service was (barring whatever shady analytics the company might be doing with data about people's music tastes) quite a nice thing. Then in May 2020, it announced that shutdown would be happening "later this year" and provided tools to migrate users to its YouTube Music service. But if you want a new cloudy home for your music, one far from the clutches of the Alphabet corporation, consider setting one up on your own.

Unlike streaming video, it doesn't take much in the way of CPU power to run your own music server. So a cheap virtual private server (or indeed a Mythic Beasts Pi hosting offerings that we mentioned in our cover feature last issue) will be fine. Or you may prefer to host things on your own hardware, perhaps making use of an old machine or a Raspberry Pi.

A popular application for doing this used to be the Java-powered, closed source Subsonic (www.subsonic.org).

Subsonic can handle video too, but it's first and foremost a music player. It'll make easy work of your podcasts and can stream to DLNA, Sonos, Chromecast and various other hardware. It integrates with Last.fm



Consuming media

We haven't talked much about media players, beyond streaming to a web browser or app. That's all well and good, but it would be remiss of us not to mention the other options here. The venerable Kodi (formerly XBMC, the Xbox Media Center) is still alive and well (and so unfortunately are all the nefarious add-ons and repos that give it a bad name). Kodi can be installed on any distro, as well as tablets and other devices, but our preferred way to run it is on the Raspberry Pi, on top of either LibreELEC or OSMC. Kodi can connect to your Plex install via an add-on, or play music that you've already shared over your network.

If you want to turn your Raspberry Pi into a stellar bit of hi-fi kit, then look no further than the impressive array of DAC HATs available from the likes of IQAudio and HiFiBerry. Just add a large amplifier (or a small HAT-sized one if you prefer) and a large pair of speakers and get Volumio booted up. Another popular option is Mopidy, which like Volumio is based on MPD (Music Player Daemon). All of these can be controlled via the free MPDroid app. If you just want a simple media player for your desktop (and the one bundled with your distro doesn't satisfy) then we never hesitate to recommend Mpv (something like a continuation of MPlayer) or VLC (the Qt-based multimedia powerhouse).



Don't lose your Google Play Music library

Keep the music library that you built by transferring to YouTube Music now

TRANSFER TO YOUTUBE MUSIC

NOT NOW

The seasons turn and Google marks the occasion by killing off yet another one of its more useful services.

for audio scrobbling and artist data, fetches lyrics from Chartlyrics and grabs reviews from Wikipedia. And as you'd expect, it handles all kinds of formats, even Flash (shudder). Tagging support is provided by JAudiotagger.

We recommend you check out Subsonic. We'd cover it here, but we can already hear people grumbling about proprietary software. And there hasn't been a major release for two years. There are a number of forks of it, though (based on the last open source release back in 2016): Madsonic, which used to be open source, is popular. Libresonic, and its 2017 fork Airsonic seem to be the only

FOSS descendants around today. So let's look at installing Airsonic, which needs Java and Tomcat but will happily run on a Raspberry Pi 3 (although if you have a large music library you probably want to use external storage rather than an SD card).

Get Airsonic up and running

Browse to the Airsonic GitHub page and in the Releases section download the latest .war package, or use the command below (do check for a new version on the releases page) if you're connected remotely to your box:

```
$ wget https://github.com/airsonic/airsonic/releases/download/v10.6.2/airsonic.war
```

It's worth following the official instructions (<https://airsonic.github.io/docs/install/war-standalone>) and checking the signed checksums too:

```
$ gpg --keyserver keyserver.ubuntu.com --recv 0A3F5E91F8364EDF
$ wget https://github.com/airsonic/airsonic/releases/download/v10.6.2/artifacts-checksums.sha.asc
$ gpg --verify artifacts-checksums.sha.asc
$ sha256sum -c artifacts-checksums.sha.asc
```

Now install the OpenJDK Java development kit:

```
$ sudo apt install default-jdk
```

If you're installing this on Raspberry Pi it's recommended to use Oracle's JDK instead. This method works on Debian 10 and Ubuntu. It's recommended to install Tomcat as well, but it's also possible to run the .war archive directly. Before we

airsonic

☆ hiphop » 0Cerebral-ate » josh martinez & sleep - the chic

Up | Play all | Play random | Add all | Download all | Edit tags | Comment

☆☆☆☆ | X Share | Search Google | Wikipedia | allmusic | Last.fm | Discogs | Player

> Refresh

Playlists

My first playlist (0)

- > Create new playlist
- > Import playlist

☆	▷	+	→	□	2	Take Em Down	Josh Martinez
☆	▷	+	→	□	3	America The Beautiful	Josh Martinez
☆	▷	+	→	□	4	Opposite Of Fair	Josh Martinez
☆	▷	+	→	□	5	Alone	Josh Martinez
☆	▷	+	→	□	6	Megaheat	Josh Martinez
☆	▷	+	→	□	7	Oregano	Josh Martinez
☆	▷	+	→	□	8	Blessing In Disguise	Josh Martinez
☆	▷	+	→	□	9	Say Goodbye Ft Zelly Rock	Josh Martinez
☆	▷	+	→	□	10	Bring On The Summer	Josh Martinez
☆	▷	+	→	□	11	Peaces	Josh Martinez

Airsonic gives you a clean and lightweight web-powered interface. It's no graphics, all goodness.

do that though, we need to set up its data directory. Replace youruser and yourgroup below with the username and group you plan on running Airsonic as. Your own username is fine, in which case you don't need to change the last command. Otherwise you'll need to prefix it with sudo -u youruser :

```
$ sudo mkdir /var/airsonic
$ sudo chmod -R youruser:yourgroup /var/airsonic
$ java -jar airsonic.war
```

All going well, you should see screeds of Java output and find the Airsonic login page running on your host at port 8080 (for example, <http://localhost:8080> if you're running locally). Log in with the default admin:admin credentials as instructed. Now, also as instructed, change that password by clicking the link. The next step is to set up media folders. A default entry for /var/music is included, but since this probably isn't where your music is stored it's safe to delete this. Add a folder that actually contains your music and give it a name, then hit "Scan media folder now" to begin the fun.

There's not much you can do while Airsonic is scanning your library, but you can add some users by visiting the Settings page. Even if you're not going to share your music with anyone, you should set up a non-admin user for yourself. There are quite granular access controls for users, including the ability to limit downloading and sharing. Now would be also a good time to hunt down

"Subsonic can make easy work of your podcasts and can stream to DLNA, Sonos, Chromecast and various other hardware."

the Dsub app (originally written for Subsonic) and install it on your mobile devices.

Assuming the library scan is complete you can now browse through your collection and see what Airsonic thought of your naming schemes. We didn't have as much luck as we did with Plex here, which forgave our genre folders. Airsonic insisted that these were albums too. But things were easily rearranged. Compared to Plex, Airsonic might seem a little spartan, maybe even clunky. But it uses minimal resources (CPU-wise anyway, if you have a large library you might have some difficulties if you're running on less than a 1GB Pi). Airsonic can help you set up playlists and subscribe to podcasts. And so long as you've got ffmpeg installed on the host it can do transcoding as well. Oh, and you can install it as a Docker image too.

If you like the Airsonic approach, but want something that perhaps fits in better with your hosting environment, try looking at Ampache. If you already have a LAMP stack set up then with very little work (cloning the repo and adding a virtual host entry) you can have a PHP-powered music streaming system. You don't even have to use Apache –

Nginx, Caddy and Lighttpd are supported too.

Bring the funk

Readers familiar with our ways will know we're all about decentralisation. We're also fans of funk and whales, so when we read about Funkwhale we simply had to share. Like whales, Funkwhale users can align themselves with a pod. This is a group of users who communicate and share tracks with one another on a particular Funkwhale instance. Like one of our other favourite decentralised things, Mastodon, pods can federate – communicate with one another and discover new connections, music and social groupings. The Funkwhale web client is a Python-Django-Gunicorn affair and we were pleased to see a Docker image besides a traditional install script. We'd urge you to check it out at www.funkwhale.audio.

And here ends our jaunt into the world of media. Do let us know how your installations go, what you end up watching, and what we should have done differently. Try and not get spooked too, it's just a trick of the light. ■

System News

As the GPU shortage continues, Mark Williams discovers unsavoury tactics in the supply channel.

What is going on with the GPU market at the moment? It's running so hot right now that all new GPU releases are selling out in minutes, there are waiting lists, shipment update pages and even raffles for the 'opportunity' to buy a card. The RTX 3080 in particular is just a myth to most, as supply slowly trickles out to fulfil orders that were originally placed all the way back on launch day, two months ago!

The latest GPU to enter the fray is the RTX 3070 with its RTX 2080 Ti-levels of performance at half the price, and as you can appreciate, it too sold out very quickly as well. However, supply of the 3070 is stronger and for system builders like Aftershock PC its "been lucky to secure lots more stock of the 3070 prior to launch than was available with the 3080 launch, so will have plenty to fulfil all orders".

Most of the supply shortage blame seems to be laid on Samsung's custom, Nvidia-tweaked 8nm process, and while that may be true, there's equal blame being laid on the supply of the more exotic GDDR6X memory used on the 3000 series cards.

Whatever the issues are, supply is severely constrained and will continue to be, for Nvidia, well into the new year.

Talking with Richard from Aftershock PC about the supply of RTX 3000 cards, he mentioned that "we have actually had plenty of stock of the 3070 and 3090 since their respective launches, so no issues there. For the 3080s we have had to commit to massive amounts of motherboards in order to get stock to fulfil orders."

For a boutique shop like Aftershock that only sells whole computers and not individual parts, having adequate GPU supply for its needs isn't all that surprising. What was surprising is what Richard said when asked about the "massive amounts of motherboards" they must commit to buy from its supplier to be able to stock 3080s. Richard explained "buying 10 motherboards to get one 3080 is tough when we only sell whole systems. It means we have a heap more motherboards than we can match up with



"What was surprising is what Richard said when asked about the 'massive amounts of motherboards' they must commit to buy from its supplier to be able to stock 3080s. Richard explained 'buying 10 motherboards to get one 3080 is tough'."



MARK WILLIAMS
Mark is an IT professional with a strong interest in voiding warranties.

30-series GPUs. Talking to our partners overseas, this seems to be a worldwide system imposed by distributors to try and clear out their stock of motherboards since the 3080s are in such short supply. Apparently during the start of COVID-19, each of the distributors purchased a giant amount of motherboards and things then slowed (unexpectedly) with all the Nvidia mess, so they were stuck with a tonne of motherboards. It seems to be the same case with all the distributors we are buying from."

Richard further explained that

it was mostly B450 and B365 motherboards that they were forced to buy initially, but that's now 'relaxed' to be any motherboard chipset type.

What a bizarre side effect of the GPU shortage – the purchasing of ten motherboards as collateral to secure one RTX 3080. Let's hope the RX 6000 series launch goes smoothly and helps alleviate this insanity, not to mention bring some competition back to the top end once again to put downward pressure on the ever-increasing prices.

Shop Talk

How is the launch of the RTX 3070 shaping up for you relative to the 3080? Do you have much if any stock available? Has AMD's sales guidance for RX 6000 changed the way you're handling GPU sales?



RICHARD, AFTERSHOCK PC:

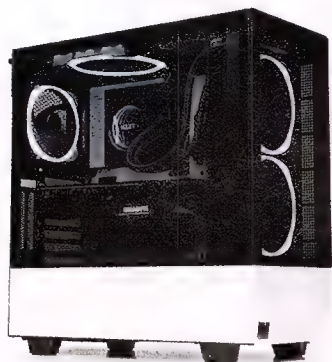
"We have been lucky to secure lots more stock of the 3070 prior to launch than was available with the 3080 launch so we will have plenty to fulfil all our orders. As such, the launch is looking pretty good at the moment. Not sure how the stock levels are going to be going forward, but as with all 3000 series, it is not looking like it

will be any good until next year.

There does seem to be a lot of talk about people holding off on getting the 3070 in anticipation of the RX 6000 series release (and also the new Ryzen release), however speaking with distributors it seems it will still be quite a while before we can get our hands on third party RX cards. ■

Market snapshot

An overview of typical systems in today's market.



\$3,602 | tinyurl.com/APC488PLE

PLE Computers Halo 3070

This white and black beauty, like the other Intel-based systems this month, is best suited to those looking at high refresh gaming, be it 1080p at 240Hz+ or 1440p at 144Hz. This system with the new RTX 3070 – which sports RTX 2080 Ti levels of performance – is perfect for just that as the 8GB of video RAM means that 4K gaming is mostly out of the question without DLSS usage. The water-cooled CPU will be easily capable of overlocks into the low 5GHz range and with a generous 750W power supply powering it all you won't be left wanting for more. The 1TB SSD is great to see, but the SMR-based 2TB HDD is less so, and should only be used for storage, backups and the like.

CPU: Intel Core i7 10700KF, **Cooler:** Nzxt Kraken X63 280mm AIO, **Motherboard:** Nzxt Z490 N7, **Graphics:** Gigabyte GeForce RTX 3070 Gaming OC 8GB, **Memory:** Kingston 16GB HyperX Fury Black C16 3200MHz DDR4, **Storage:** WD Blue SN550 1TB NVMe M.2 SSD, WD Blue 2TB HDD, **Power Supply:** eVGA Supernova GA 750W, **Case:** Nzxt H510 Elite.



\$3,224 | tinyurl.com/APC488AFT

Aftershock PC The Vault

Seeing this much performance packed into something the size of a shoebox is always great to see. Rocking an 8-core 3rd gen Ryzen processor, it has all the CPU horsepower most users will need – unless you're looking for ultra-high refresh gaming – where this will hold back the RTX 3070 at sub 4K resolutions, and so is best suited to those looking to use higher detail game settings. The sole mass storage drive, while fast, is only 512GB so you might find yourself popping in another M.2 SSD into the spare slot on the motherboard later on. It is the smallest in both stature and asking price of the systems this month, giving it a good bang for your dollar rating.

CPU: AMD Ryzen 7 3700X, **Cooler:** Nzxt 140MM AIO Watercooling (H1), **Motherboard:** Gigabyte B550I Aorus PRO AX, **Graphics:** Gigabyte Eagle RTX 3070 OC Edition 8GB, **Memory:** 16GB DDR4 Corsair Vengeance RGB PRO 3600MHz, **Storage:** 512GB M.2 NVMe SSD, **Power Supply:** 650W 80+ Gold Certified PSU (Included with Nzxt H1), **Case:** Nzxt H1 White.



\$3,399 | tinyurl.com/APC488SCD

Scorptec Aorus RTX 3070

This system is quite similar to the PLE offering this month but is cheaper. With the same CPU and GPU, the other differences come from elsewhere. A doubling of system memory is not what we would expect and it's the biggest of several pluses over the PLE system. A non-SMR HDD is in a small way also better, as is the 360mm AIO water cooler offering more surface area than the PLE system's 280mm AIO and thus theoretically more cooling performance.

The only real downsides are the smaller 500GB SSD, the smaller 650W power supply and a less common 4x8GB RAM configuration. With the relative cost savings, though, this is a system that's hard to pass up.

CPU: Intel Core i7 10700KF, **Cooler:** Thermaltake Floe RC360, **Motherboard:** Gigabyte Aorus Z490 Elite AC, **Graphics:** Gigabyte Gaming RTX 3070 OC 8GB, **Memory:** Thermaltake ToughRAM RC 32GB 3200MHz DDR4, **Storage:** Seagate FireCuda 510 500GB M.2 SSD, Seagate BarraCuda 2TB HDD, **Power Supply:** SilverStone Strider 650W, **Case:** Thermaltake Level 20 MT ARGB Black.

\$3,899 | tinyurl.com/APC488PCC

PC Case Gear Spectral 3070

Sporting this month's highest price, this system brings with it, at the time of writing, arguably the second-best gaming CPU available on the market in the 10-core i9 10850K. This will allow you to push the new RTX 3070 to its limits on high refresh monitors, particularly at 1080p where the CPU is the primary bottleneck. This system is certainly CPU-heavy on performance, so as long as 4K monitors aren't on your horizon and you can utilise those 10 CPU cores outside of games, this could be a well-balanced rig for you. The 32GB of RAM is nice and will give this system legs for some time to come. The well-sized mass storage and power supply also show that this system will last any buyer quite a while before needing to upgrade.

CPU: Intel Core i9 10850K, **Cooler:** Cooler Master MasterLiquid ML240R ARGB AIO, **Motherboard:** MSI MAG Z490 Tomahawk, **Graphics:** Galax GeForce RTX 3070 SG 8GB, **Memory:** Corsair Vengeance RGB Pro 32GB 3200MHz CL16 DDR4, **Storage:** Adata XPG SX8200 Pro M.2 NVMe SSD 1TB, Seagate Barracuda 2TB HDD, **Power Supply:** Super Flower Leadex III Pro ARGB 750W, **Case:** Phanteks Eclipse P600S Tempered Glass Anthracite.



PC BUILDER

Budget

Punching above its price.

We've seen major price drops on both our builds, and some significant part shuffles to prepare for our new cases dropping next issue. And it's about time! For our AMD build we've opted to go for the Ryzen 3 3100 quad-core processor. It's a favorite of ours at the moment for budget builds, complete with four cores and eight threads. OK, so it's not about to win any rendering competitions, but only two years ago this was the high-end staple core count for all of us in the consumer market, and it's more than enough for any budget escapades into gaming, or rendering. On the Blue side of the field, we've gone and grabbed one of those shiny new Intel Core i5-10400s. Ever so slightly stockier than our AMD competition, this six-core, 12-thread chip packs a punch, and best of all comes with a cooler as standard straight out of the box.

We've also swapped out the GPUs for something a little more 1080p-reasonable. Both cards, AMD and Nvidia, achieve on average 60fps across a myriad of titles at 1080p, making them perfect picks for our new parts list, and on top of that we've also added some shiny upgrades to storage, in the form of a 256GB Samsung 980 Pro PCIe 4.0 drive for the AMD rig and a 256GB XPG SX8100 PCIe 3.0 SSD for Intel. AMD still has the upper hand here,

and thanks to that Ryzen 3 3100, you can finally take advantage of the new connection standard, unlike with the 3200G and 3400G.

Lastly, we've also swapped out our Linux budget OS for an OEM Windows Home key. Although ideally you'll want a permanent license attached to your Microsoft account so you can pull it across

from one build to the next. We'd previously priced this at \$140, but \$60 is a more realistic price for this OEM OS key, and it's available for much less, too, but we just have to be careful and suspicious of the really cheap offers.



"Both cards, AMD and Nvidia, achieve on average 60fps across a myriad of titles at 1080p, making them perfect picks for our new parts list."

AMD INGREDIENTS

PART		PRICE
CASE	BITFENIX NOVA TG	\$95
PSU	450W GIGABYTE GP-450B 80+ BRONZE NEW	\$59
M/BOARD	ASROCK B550M PRO4 NEW	\$140
CPU	AMD RYZEN 3 3100 NEW	\$150
GPU	GIGABYTE GEFORCE GTX 1650 SUPER WINDFORCE OC 4G NEW	\$270
RAM	16GB (2 X 8GB) GEIL ORION @ 3,600MHZ NEW	\$120
SSD	250GB SAMSUNG 980 PRO M.2 PCIE 4.0 NEW	\$150
HDD	1TB SEAGATE BARRACUDA HDD	\$65
OS	WINDOWS 10 HOME 64-BIT OEM NEW	\$60
PRICE:		\$1,109

INTEL INGREDIENTS

PART		PRICE
CASE	BITFENIX NOVA TG	\$95
PSU	450W GIGABYTE GP-450B 80+ BRONZE NEW	\$59
M/BOARD	GIGABYTE B460M AORUS PRO M-ATX NEW	\$179
CPU	INTEL CORE I5-10400 NEW	\$260
GPU	GIGABYTE RADEON RX 5500 XT 4GB NEW	\$300
RAM	16GB (2 X 8GB) GEIL ORION @ 3,600MHZ NEW	\$120
SSD	256GB XPG SX8100 M.2 PCIE 3.0 SSD NEW	\$80
HDD	1TB SEAGATE BARRACUDA HDD	\$65
OS	WINDOWS 10 HOME 64-BIT OEM NEW	\$60
PRICE:		\$1,218

PC BUILDER

Mid-range

PCs for most of us.

And there goes the plans to lop off some of the price... We've had to make some serious changes to both our builds this time around, opting for an AMD Ryzen 5 3600X for the AMD build. This is still a meaty six-core, 12-thread chip, with a seriously impressive clock speed and decent gaming and rendering performance too, but it is somewhat shy of the 3700X we had last issue. Sadly there have been price hikes galore (you'd have thought that these things would have dropped in price given AMD's new stuff, but hey ho).

On top of that we've paired it with a bit of a beefier cooler in the form of be quiet!'s Dark Rock 4. Rated to handle chips with a TDP of up to 200W, it will be more than enough to get the most out of that processor.

Aside from that and a tweak to the memory to bring it up to that 3600MHz mark for a boost to performance, there's not a lot to report on here. So over to the Intel build we go.

We've still managed to hold onto

that eight-core, 16-thread i7-10700 for this issue, but again we've swapped out the cooler for something with a little more style (and a little less beige). We've also stuck with the same graphics card across both builds. Right now, the mid-range GPU arena is in some serious upheaval, and to that end, until the RTX 3070 finally drops next issue, the 5700 is the best-value card out there.

We've also managed to snag a deal on a swanky MSI

motherboard, and sunk our teeth into a pretty sweet saving on Western Digital's WD Black SN750 PCIe 3.0 M.2 SSD. It's the only drive we've seen that's been able to give Samsung a run for its money in the 3.0 space, and for \$130 for 500GB it makes the perfect OS drive, that's for sure. Combine that with a set of fancy 3200MHz memory (because even Intel needs a little memory love every now and then), and you're on the way to one heck of a build.



AMD INGREDIENTS

PART		PRICE
CASE	FRACTAL DESIGN MESHIFY C	\$150
PSU	650W CORSAIR CX650	\$140
M/BOARD	ASUS TUF GAMING X570-PLUS	\$350
CPU	AMD RYZEN 5 3600X NEW	\$380
COOLER	BE QUIET! DARK ROCK 4 CPU COOLER NEW	\$140
GPU	MSI RADEON RX 5700 MECH GP OC 8GB	\$500
RAM	16GB (2 X 8GB) GEIL ORION @ 3,600MHZ NEW	\$120
SSD	500GB GIGABYTE AORUS GEN4 SSD NEW	\$165
HDD	1TB SEAGATE BARRACUDA HDD	\$65
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
PRICE:		\$2,070

INTEL INGREDIENTS

PART		PRICE
CASE	FRACTAL DESIGN MESHIFY C	\$150
PSU	650W CORSAIR CX650	\$140
M/BOARD	MSI MPG Z490 GAMING PLUS NEW	\$330
CPU	INTEL CORE I7-10700	\$500
COOLER	NOCTUA NH-U12S CHROMAX.BLACK NEW	\$155
GPU	MSI RADEON RX 5700 MECH GP OC 8GB NEW	\$500
RAM	16GB (2 X 8GB) G.SKILL TRIDENT Z RGB @ 3200MHZ NEW	\$140
SSD	500GB WD BLACK SN750 M.2 PCIe 3.0 NEW	\$130
HDD	1TB SEAGATE BARRACUDA HDD	\$65
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
PRICE:		\$2,170

PC BUILDER

Turbo

Maximum overkill.

That's one heck of a price difference between the two builds we have here, that's for sure. We've recalibrated our two systems one last time, before we convert them into far more grandiose platforms for next issue (with the much-heralded new cases, of course).

For our AMD build we've splashed the cash just a touch and gone with a brand new, slightly pricier motherboard in the form of Gigabyte's Aorus Ultra. It's a beast of a board, and Gigabyte has come a long way in the last few years in regards to its BIOS settings, so it's good to see the brand make headway into more premium motherboard offerings. On top of that we've opted for a Corsair RM-series power supply, and also splurged on the PCIe 4.0 SSD, replacing our trusty early-adopter drive for the newly released and far more mature Samsung 980 Pro.

And of course, we couldn't leave this issue without going for a decent RTX 3080 graphics card as well. We're using the same card in our Intel build this time around too – MSI's Ventus RTX 3080 tri cooler. By the time you read this the drivers should be more than mature enough to



handle the extra clock speeds, and those early-adopter crashes should be a thing of the past. It comes with one caveat of course, which is that right now these cards are pretty much entirely out of stock. Soon, though, Nvidia should have somewhat resolved that, and right now there simply isn't a better card for the coin. If 4K gaming is your thing, then the RTX 3080 is a true king of frame-rendering.

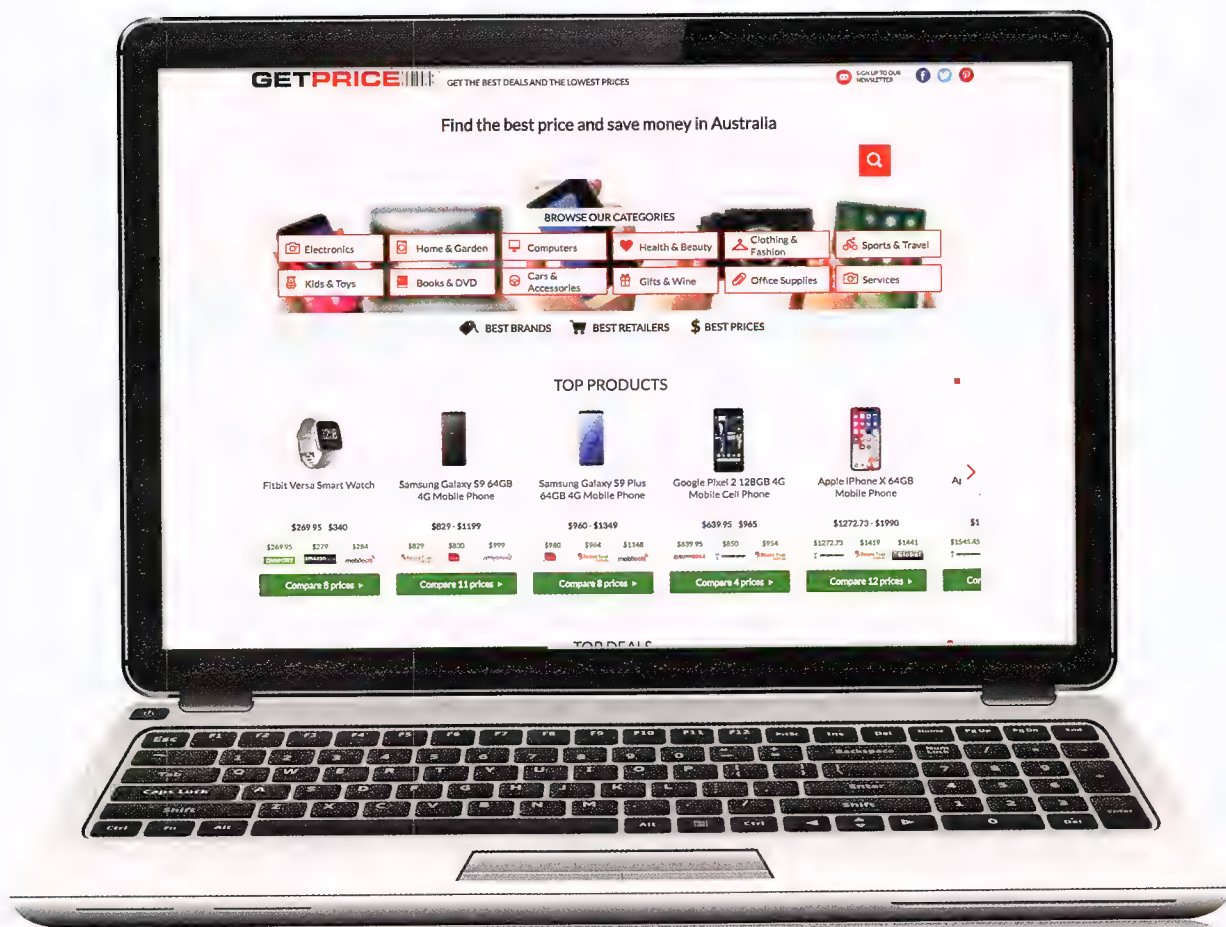
Moving onto our Intel build, and we've kept things resolutely conservative for this issue, but there has been one big change: We dropped that hefty \$480 motherboard from last issue, and have instead opted for this stellar board from Asrock. At just over \$210 cheaper it gives us a bit of wiggle room to play with for our slight PCIe SSD upgrade.

AMD INGREDIENTS

PART		PRICE
CASE	NZXT H710I	\$310
PSU	750W CORSAIR RM750X MODULAR PSU NEW	\$135
M/BOARD	GIGABYTE X570 AORUS ULTRA NEW	\$480
CPU	AMD RYZEN 9 3950X	\$1,150
COOLER	CORSAIR ICUE H115I RGB PRO XT 280MM	\$200
GPU	MSI GEFORCE RTX 3080 VENTUS 3X 10G NEW	\$1,400
RAM	32GB (2 X 16GB) G.SKILL TRIDENTZ NEO @ 3600MHZ	\$260
SSD	1TB SAMSUNG 980 PRO M.2 PCIe 4.0 NEW	\$370
HDD	6TB SEAGATE BARRACUDA HDD	\$250
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
PRICE:		\$4,615

INTEL INGREDIENTS

PART		PRICE
CASE	NZXT H710I	\$310
PSU	850W NZXT C850	\$195
M/BOARD	ASROCK Z490 EXTREME4 NEW	\$270
CPU	INTEL CORE I9-10900K	\$1,000
COOLER	COOLER MASTER MASTERLIQUID ML360R ARGB 360MM	\$180
GPU	MSI GEFORCE RTX 3080 VENTUS 3X 10G NEW	\$1,400
RAM	32GB (2 X 16GB) CORSAIR DOMINATOR PLATINUM @ 3000MHZ NEW	\$190
SSD	1TB WD BLACK SN750 M.2 PCIe 3.0 NEW	\$290
HDD	6TB SEAGATE BARRACUDA HDD	\$250
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
PRICE:		\$4,145



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PC MASTERCLASS

IT'S TIME TO BUILD A PC.



BUILD IT

Mystical Monster

This issue, Nvidia's new Ampere architecture meets overkill RGB.

Come on now, you knew it was coming. You can't launch a major new GPU architecture and a swathe of graphics cards and expect us here at *APC* to not go out and put together a ridiculously over-the-top, super-powerful, super-expensive machine. It's in our nature. So that is exactly what we're doing here today.

However, if I'm honest, it being this colourful is a happy accident



ZAK STOREY

Zac's never met a machine he didn't want to disassemble and rebuild again.

"The ambition? Well simply put, to see how well MSI's GeForce RTX 3080 Gaming X Trio can perform in an actual PCIe 4.0 rig, with a fairly solid base spec."

– depending on your point of view anyway. It's certainly not something we set out to achieve, but it's part and parcel of working with the brands we do – more on that later.

So what's the ambition? Well simply put, to see how well MSI's GeForce RTX 3080 Gaming X Trio can perform in an actual PCIe 4.0 rig, with a fairly solid base spec. But this is our first build with an aftermarket card, and that raises a lot of questions. There's been some furore surrounding capacitors on these cards, especially the aftermarket variants, as they seem to be running at the absolute limit (built to Nvidia's specs), and any

attempt to overclock leads to blue screens and crashes. Secondly, these things are seriously big, and as the cards are known to draw more power than ever before, I want to take a look at a) just how noisy they are, and b) whether the temps are actually that bad.

That's actually one of the big advantages of being a tech journalist in print: We don't have to rush our work to be the first out. We can take our time, find any bugs, and report on them too, giving you all the best information. Let's dive in!

Part selection

So then, on to the parts list. What have I got for this rig? Well first up is the processor, and at its core I'm running an AMD Ryzen 7 3800X. This is one of the more top-end processors from AMD for this current generation. It's got eight cores, 16 threads, and a beefy 4.5GHz turbo clock speed at max. Single-core performance is solid, and it's got plenty of headroom in games too. Combine that with PCIe 4.0 support and a bevy of additional features to get the most out of it at stock, and it's a good pick for this test system.

Moving on to memory, and I'll be pairing this with 32GB of G. Skill's Trident Z NEO memory at 3600MHz, which is sort of the sweet spot for 3rd-gen Ryzen. I'll be slotting all of that together inside one of Corsair's latest 4000D Airflow chassis, and then I'll complete the look with a

Corsair iCUE H150i Elite Capellix AIO liquid cooler too.

And as for the wild cards? Those are reserved for the storage and power supply. I've gone with the Samsung 970 Evo Plus 1TB, just for testing purposes, and one of be quiet!'s latest Dark Power Pro 12 1200W 80+ Platinum PSUs. The latter was actually a stand in; I was intending to use one of Corsair's latest CX750F RGB power supplies as well, just to really go for RGB overkill, but sadly it arrived a day after our photoshoot, due to that pesky coronavirus delaying shipments from Taiwan. That said, the Dark Power Pro series has long been a workhorse of ours, and this one will go on to become our permanent test-bed PSU as well, at least once we're allowed back in an office again.

PART		STREET PRICE
CASE	CORSAIR 4000D AIRFLOW ATX MID TOWER CASE BLACK	\$130
MOTHERBOARD	ASUS ROG CROSSHAIR VIII HERO	\$600
CPU	AMD RYZEN 7 3800X	\$600
GPU	MSI GEFORCE RTX 3080 GAMING X TRIO	\$1,470
MEMORY	32GB (4X8GB) G.SKILL TRIDENT Z NEO DDR4 3600 CL16	\$300
PSU	1200W BE QUIET! DARK POWER PRO 12 80+ TITANIUM	\$550
STORAGE	1TB SAMSUNG 970 EVO PLUS	\$270
CPU COOLER	CORSAIR ICUE H150I ELITE CAPELLIX	\$300
OS	WINDOWS 10 HOME 64-BIT OEM	\$60
TOTAL		\$4,280

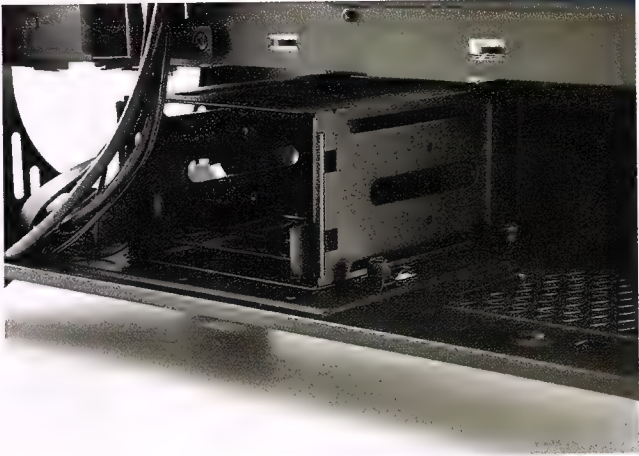
“There’s a reason we don’t award perfect scores at APC often, and that is because very few products are flawless. There’s always something, and here we have another example of that.”



01 TRIPTYCHAL BRILLIANCE

Apparently this style of image is called a triptych, according to my photographer. I just asked for three side-by-side shots comped together, but hey, you learn something new every day. I want to highlight these three areas specifically to give some understanding as to what makes the 4000D Airflow such an impressive case, and it's all about that attention to detail.

This is an \$130 chassis, and it's not a lot for what you're getting, really. The yellow thumbscrews, the subtle branding and tabs, the new design language, and yet with an attention to performance detail that just has to be admired, all make this one of my favorite cases of 2020. It's a big reason why I've picked it not only for this build, but also for our Blueprint budget case going forward.



02 NOT WITHOUT FLAWS

That said, there's a reason we don't award perfect scores at APC often, and that is because very few products are flawless. There's always something, and here we have another example of that. During my usual chassis stripdown (basically remove everything that's not needed from the case and call it a day), I noticed that this hard drive caddy has retainable Phillips-head thumbscrews located inside the case itself. Now that's fine, but they're factory tightened to an unbelievable degree, and it's darn hard to get a screwdriver in there to undo them. I ended up using a small set of grips just to loosen them off enough to get my fingers in there and get the caddy out.

Why not just leave the caddy in? Well, the Dark Power Pro 12 is a beast of a PSU. In fact I've never seen anything quite so large, especially in a chassis of this size.



03 MOTHERBOARD MANSLAUGHTER

Seriously, how expensive are motherboards getting these days? This once "mid-range" Hero board from Asus is \$600! That's more than the cost of the eight-core, 16-thread processor at its heart. Just crazy. But one thing I can say is that this thing looks stellar, and has some serious connectivity to boot, including multiple PCIe 4.0 slots, a sizable VRM cooling solution, and more rear I/O than you can shake a cat at.

I'm pre-installing the CPU here before placing the board in the chassis, and also making sure that the stock back-plate is still required for Corsair's fancy new AIO Capellix coolers.



05 COOLER MOUNTING

Anyone who's familiar with Corsair's AIO mounting design for AMD chips will recognise the mounting mechanism here. Attach the correct AM4 mounting bracket to the CPU block, then carefully pre-install the two thumbscrews/nuts and hook screws on the other side. Then hook the CPU block over the two notches on the stock bracket, and carefully tighten. Remember to remove the plastic label from the CPU block base, and add a small blob of thermal paste too.

It's then a case of running the CPU pump and RGB cables up and out of the way round the back of the case, plugging them in to the RGB fan controller that comes with the cooler, and one to a fan header on the board.



04 INTAKE ANNOYANCES

For our AIO installation, given the impressive-looking airflow in the front of the 4000D, I've decided to place the 360mm radiator in the front of the chassis, drawing cool air in via those three static pressure-optimised RGB fans. Now this does mean that we'll see slightly higher GPU temps, as the air will be getting heated via the radiator as it passes through, but on the whole that should only be around 2-3C higher than if we were using this as an exhaust instead in the roof.

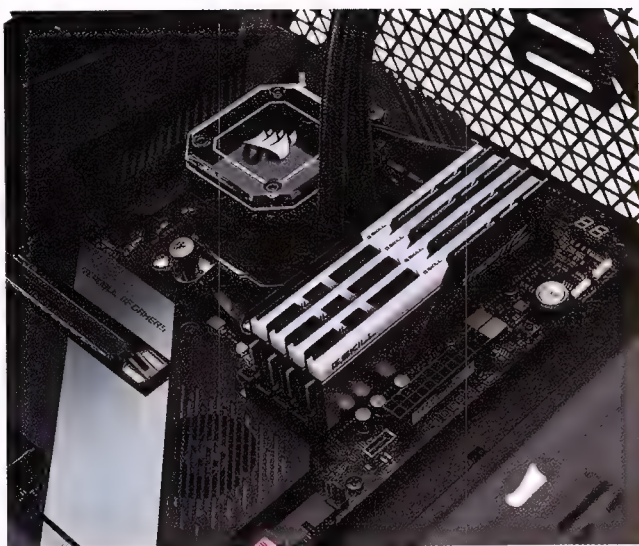
One thing to note is it is an utter nightmare to install the three fans to the radiator and the front of the chassis. Take your time, use two screws per fan at first, and don't tighten them all the way until all three fans are in position and are secured to the radiator. You'll need as much wiggle room as possible.



06 STORAGE CONFUSION?

Why so little storage? Well simply put, this is all due to this thing being set up as a test-bed first and foremost. Although it's a good platform for a build, I'm only including a single 1TB Samsung 970 Evo Plus for our OS and testing games.

The long-term intention is to swap out the processors and see at what point in the Ryzen product stack the processor becomes the bottleneck at 1080p and potentially even 1440p.



07 RAMMING SPEED!

To ramp up the RGB goodness I've gone for a kit of G.Skill's Trident Z Neo memory – 32GB of it. Complete with a 3600MHz frequency and a C16 latency, it's been optimised for Ryzen processors. It doesn't amount to a whole lot in terms of performance in the real world, but it does mean I should end up with less motherboard incompatibility and instability.

There's been a lot of different variants of G.Skill's Trident Z RGB memory, and although not quite as bright as the Capellix LEDs used in the likes of Corsair's Dominator Platinums, these are some of the brightest we've seen, and it's hard to argue with the styling either.



09 CABLES FIRST?

I decided to do something different with this build and to actually install and route the majority of the cables first, before installing the power supply. Typically what we recommend is that you identify the cables you need, plug them into the modular supply, then slot that in the chassis.

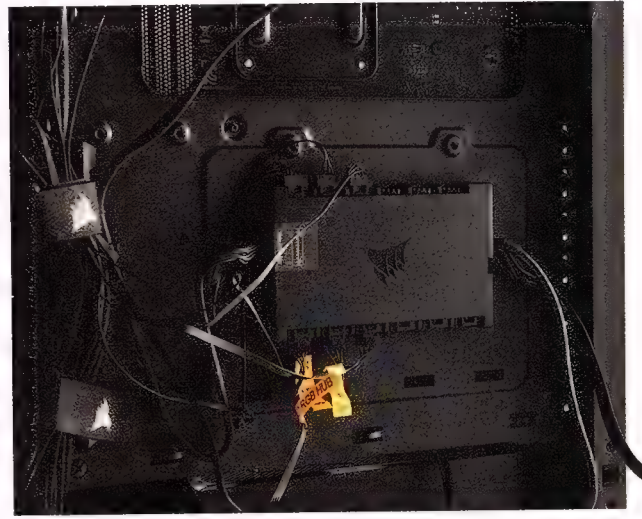
Given the size of the DPP12, and mostly because I wanted to see if this was easier, I've opted to try it this way instead. Turns out it's a bit more of a pain in the butt, and I should've stuck with option one. You also can't install all the cables, as the graphics card isn't in either, and there's various I/O stuff that requires power too. So here I've installed the 24-pin, the CPU power, and then moved on to all the front I/O cables as well.



08 GOLIATH SUPPLY

This PSU choice was a bit of a last-minute decision. I was expecting Corsair to deliver one of its latest CX RGB power supplies. The fans in these latest PSUs feature RGB lighting, so you can face it up into the chassis to add a bit of extra illumination through the PSU cover, or face it downwards to get a sort of soft underglow at the back of the rig. They're fairly inexpensive too, although they come with an 80+ Bronze rating and tap out at 750W.

Unfortunately it didn't arrive until the day after our shoot, and so I had to opt for a significantly pricier alternative we had in our storeroom. So here we have the latest Dark Power Pro 12 from be quiet! It's seriously big. Even the box itself is insane. I've popped in a 120mm fan here for scale, but it's just utterly massive. There are no gimmicks or RGB lighting, just hyper-quiet, monstrous power-supplying goodness to enjoy.



10 BLESSINGS AND BINDS

With everything in position, it's time to install the included RGB and fan controller bundled with the cooler. Annoyingly the fans' RGB cables have a proprietary connectors that plumb straight into this little controller box here. You then power that via SATA power, and connect it to the motherboard via USB 2.0 cables.

Fortunately the fan header itself is still of the PWM variety. This could be a blessing or a curse, depending on your preference. I've removed the two SSD caddies from the back of the 4000D here, and then attached the Corsair controller with two adhesive strips included with the cooler. It's neat, gets the job done, but is a bit annoying for cable management.





11 GOING BEYOND THE LIMIT

This is something rarely seen on power supplies under the 1000W marker, but on the more premium solutions can be a common sight. It isn't your standard kettle lead that's needed for this, but instead a C19 lead. Unlike the standard kettle lead, these can handle up to 16A of current (as opposed to 10A), and are more often found in industrial applications than in the world of the common PC. Be quiet! includes a cable as standard with the PSU, but be warned: The cables are significantly thicker and better insulated than their more common counterparts.



13 ALMOST FINISHED?

And there you have it, I'm almost completely wrapped up with the build here. There's just a tiny bit of cable management to not really wrap up in the rear, and we'll be good to go. So a few things to note.

I utterly adore those little Velcro cable straps included with the 4000D Airflow; they actually have a plastic bracket attached to them to thread the Velcro through, which helps, and each one is of course braided with that Corsair logo too. You also get a few more of these in the case accessories box.

And the eagle-eyed among you will probably have spotted the cable-tidy bar that's running down there as well, which is not too dissimilar from those that can be found in the original Nzxt cases.



12 MONSTROUS ANOMALIES

There's no other way of saying it: This card is huge. It is an absolute juggernaut of a graphics card. The cooler is easily a three-slot, and on top of that it comes with a huge support bracket that needs placing underneath, taking up a grand total of six PCIe slots in the case itself.

It's a good job that Nvidia doesn't support SLI anymore, because you're not going to have much space for a second card. On top of that, check out all those PCIe power connectors! It's worth noting that this is just the standard Trio Gaming X card, not some hyped-up super EVGA Black Edition, or something crazy like that. On the plus side, it doesn't have one of those funky power connectors seen on the middle of the Founder's Edition cards, so it's far cleaner.



14 DESIGN SWAPS?

But what if you're fed up with that CPU block design? Well you can swap it out for something different. The plate on top is secured via four Allen-key screws. Simply unscrew them, and you can swap them out for this clear bracket, or your own design. The white you're seeing isn't on the plexi bracket itself, but is actually the frosted acrylic sitting on top of the Capellix LEDs underneath to help diffuse the light.

Any downsides? Well Corsair includes a ridiculous plastic Allen key to undo them, and it's awful. Apparently this is to ensure that you don't damage the threads on the screws, or over-tighten them, but our sample didn't work, so I threw it out and opted for a metal one instead.



01

We sort of understand what MSI is trying to do with this light bar on the graphics card, but as you can see from G.Skill and Corsair above, light diffusing clearly isn't the design team's biggest strength.

02

You can theoretically install a PCI device underneath this GPU support bracket, but a word of warning: It's a pain in the butt to install to begin with.

03

You can just about see it here, but Corsair's got a lot of subtle branding all over the 4000D Airflow, from the model name on the right of the PSU cover to the new font and yellow square lining the rear-most cable cover bar.

Concluding thoughts

All in all the build process for this rig was fairly smooth. It's funny: Year after year I've been building systems, and I'm not sure if it's a combination of more experience and a particular procedure I follow, or whether it's chassis design getting better, but it is so easy now to build your own rig. I can't stress that enough. If you've spent any time reading *APC*, and you're still worried about building your own rig, or don't want to stress yourself with the time it takes, believe me, you've got nothing to worry about, you're more than capable. I'm positive pretty much anyone can build a system, and in not a lot of time too – unless you're dabbling at the more extreme ends, such as with liquid cooling.

Even looking at this build it's hard to think of anything that could easily go wrong. There's some housekeeping stuff perhaps. You could wear woolly socks and build it on a fresh carpet, or accidentally knock off a capacitor (which requires a lot of effort), or use

conductive thermal paste and spill it all over the socket (although there's very little of that conductive stuff left out there at this point). But aside from that, if you've spent time reading a guide or examining the process of building a PC, it's hard to go wrong. Everything's notched a certain way, or designed to minimise the chance of breaking things. In fact, I reckon the only thing still left that poses any sort of danger is Intel's LGA socket, or AMD's processor pins, and even then you're dealing with that situation for all of about two minutes, if that.

All that aside, how does it perform? The RTX 3000 series is a game-changer for gaming at 4K. Here we're comparing it against the Hydra Mini from a few issues back. The difference between the two extends to about \$300, which mostly falls on the processor, motherboard, and power supply. Additionally the Hydra Mini features an Intel Core i5 processor, while this one houses the AMD

Ryzen 7 3800X, which is somewhat slower for gaming. With similar original price points, the two cards make for a good comparison.

What are we seeing? Well, average framerates in *Shadow of War* were 81fps, *Total War* was 94fps, and *Assassin's Creed* was 59fps. That difference is huge, near 80 percent increases in most cases: Not the 100 percent increase with the 3D Mark result, but still an incredible performance boost.

On the whole it's not too noisy, and the crashing bugs that occurred at launch seem to have been fixed with the latest driver update. Is this all the card you'll ever need then? It certainly looks that way. I'm just sad I have to give the card back to MSI.

We're approaching the point where GPU performance outweighs monitor tech, and unless higher spec monitors come down in price, the need for flagship products like the RTX 3090 is difficult to justify. ■

APC LABS BENCHMARKS

	Cinebench R15 Multi	CrystalDisk 0032 Sequential	CrystalDisk 0032 Sequential	Middle-Earth: Shadow of War	Total War: Warhammer II	Assassins Creed Odyssey	3DMark Fire Strike
	Index	Read MB/s	Write MB/s	fps	fps	fps	Index
Mystical Monster	1,350	3,536	3,196	55	47	36	22,306
Zero-point	1,350	3,536	3,196	55	47	36	22,306

Our zero point consists of an Intel Core i5-10600K, 16GB of DDR4 @ 3600, a Zotac GeForce RTX 2080 Super AMP Extreme, and a 2TB Samsung 970 Evo Plus M.2 PCIe 3.0 SSD. All tests were performed at 4K with the highest graphical profile.

QUICK TIPS

APC experts solve computing problems

The APC team tackle problems across the spectrum of devices and software. Learn a new trick or fix you can use.

Blu-ray ripping

I am building a new PC to be used to rip a large collection of DVDs and Blu-ray discs, and I would like your thoughts as to which hardware would make the task faster.

I use a software package called Pavtube to do the conversion. The software has an option to speed up the process by enabling Nvidia's CUDA cores on the graphics card. I see when I look at the specs of various Nvidia graphics cards listed on Pavtube's website that there are different numbers of CUDA cores depending on the card – from 1,536 cores (GeForce GTX 1660 TI) all the way up to 4,992 (Tesla K80). Is this important? Would an even newer card – the RTX 2070 Super or RTX 2080 Super – be a better choice? Finally, would you recommend pairing this with an AMD Ryzen 5 or Ryzen 7 with 32MB of 3200MHz memory and a B450 chipset?

MARVIN MALASKY

APC responds: One word of warning before we continue – Malwarebytes flagged Pavtube as a potential phishing site when we went to test it. If you're happy with the product, then Malwarebytes is

probably being over-sensitive. Otherwise, the good news is that Handbrake (<https://handbrake.fr>) now supports NVENC hardware encoding to h.264 and h.265 formats with compatible graphics cards: Nvidia GTX 1050+ (Pascal version), GTX 1650 (Volta), or GTX/RTX 1660/2060+ (Turing), all running the Nvidia driver 418.81 or later. You'll also need to enable the options via "Tools > Preferences > Video," tick "Allow use of the Nvidia NVENC Encoders."

The NVENC codec makes a difference to ripping times, but the improvements aren't anywhere near as spectacular in Handbrake as those claimed in Pavtube. Our test machine – X470 chipset, Ryzen 2700, 32GB RAM and Nvidia GTX 1660 Super – delivered improvements of between 15-25 percent in encoding times when choosing the NVENC h.264 codec. The more CUDA cores you have, the bigger the difference, but before prioritising a new graphics card, consider image quality and file size.

The good news is that the newer

Turing-based graphics cards do deliver good quality video; previous-generation cards produce visibly inferior movies. However, file sizes are significantly larger with NVENC encodings – up to twice the size. So your choice is simple: Faster encoding times or smaller file sizes.

With this in mind, we suggest you focus more on your other components. The B450 chipset and 32GB RAM is a strong base, but choose the Ryzen 7 over the Ryzen 5 – the additional cores will do more to reduce ripping times than investing in a higher-end graphics card; the x264 codec will produce smaller files and still be able to encode Full HD movies in around 30 minutes.

Display freezes

I've got a bizarre issue that started a few months ago that I've been unable to diagnose or resolve. My system freezes randomly, sometimes several times a day, sometimes not for a day or two, but eventually it hits, and my only recourse is to do a hard reset. There are some strange oddities about this I've never seen before. First, when it freezes, the sound continues – whether a game, YouTube video or whatever. The system is locked and unresponsive, but the sound carries on until I finally hit the reset button. I can't find anything in Event Viewer and there is no BSOD or other error given.

Other peculiarities – which may or may not be related – are the fact various settings (RGB lighting settings via Aura; SB Connect 2 for my video card and sound card RGB strip) are lost after the reboot, plus I get random, intermittent sound stutters like a severe hiccup that last a second or two before going away – these seem to be tied to drive access, but I can't tell for sure since they happen so quickly and are gone.

I've recently swapped out the motherboard with an identical model to resolve a separate issue, and I've done an in-place reinstall of Windows. I've tried removing the soundcard and used just on-board



Newer GPUs will improve Blu-ray ripping performance.

sound. All drivers and the BIOS are up to date. Temps are fine according to NZXT CAM. Nothing's helped. My system specs are: Intel i7 7700K (not currently OCed), Nzxt Kraken X62 AIO, Asus ROG Strix 1080 Ti, Asus Maximus IX Formula, 32GB G. Skill, five Samsung SSDs (1x960 Pro NVMe 1TB, 1x850 Pro 256GB, 1x860 EVO 2TB, 2x850 EVO 2TB), and a SoundBlasterX Ae-5 all plugged into an Enthoo Evolv (I mention that since I'm using their PWM hub, in case that could be a factor). Any ideas? It's driving me crazy!

JOHN MEYERS

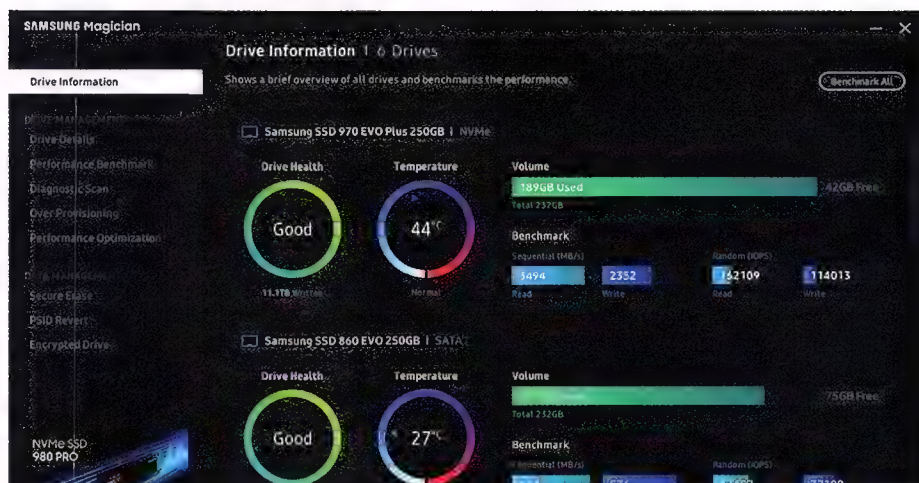
APC responds: John followed up his email with some more details – one of which was the discovery of numerous “Xvd” entries under Disk Drives in Device Manager. The Xvd entries are virtual drives created by Xbox Game Pass games installed through the MS store, which triggered the realisation that the issue began shortly after he first started using Game Pass on Windows. A further look in Event Viewer revealed a host of error entries referring to these drives – some referring to errors during paging operations, and others referring to “surprise” removals.

It seems far too coincidental that these problems aren't related – a good description of what's going on can be found at <http://bit.ly/MPCLluminati> – this would definitely place the stuttering issues at Game Pass's door, and we suspect the display freezes may also trace back here too.

First, take a full drive image using a tool like Macrium Reflect Free (www.macrium.com/reflectfree.aspx) – this gives you something to roll back to if the next two steps don't work. Step one is to uninstall Game Pass to see if the problem disappears.

If this doesn't resolve the issue, bite the bullet and adopt a nuclear approach to eliminate all potential software problems: Wipe the drive and reinstall Windows from scratch. If the problem goes away, keep taking regular drive images as you restore drivers, software, and so on – if the issue resurfaces, you'll know to focus your troubleshooting efforts on whatever was most recently reintroduced. And if the problem remains after a fresh install, restore the drive image you took, and turn your attention back to the hardware.

One component you've not mentioned troubleshooting is the video card. Given the problems are



The PCH really doesn't hurt performance on M.2 drives.

with your display, it should be your next port of call. Reset any overlocks back to their defaults, and if necessary, remove the card and run from your i7's integrated Intel HD Graphics 630 chipset, instead using the mobo's own HDMI port to hook up your display. If it does, you're looking at a possible driver problem (although the clean Windows install should have fixed that), or a failing graphics card, which will need replacing.

That said, before swapping to a new card, use Open Hardware Monitor (openhardwaredownload.com) to check for voltage and temperature spikes that might indicate a problem with the PSU or cooling, and run a test with the built-in Windows Memory Diagnostic tool to verify that there's nothing wrong with your RAM.

PCIe lane query

I recently upgraded to the Asus ROG Strix Z390-E gaming motherboard, which I'll be transferring my i7-8086K and RTX 2080 Super into. My question is about the PCIe lanes and the differences between 4x, 8x and 16x. I'm planning to install two NVMe M.2 drives – one for the OS, and a second as a game library drive. Can you please explain how these all work together?

CHRIS HUEBLER

APC responds: PCIe transfers data using serial connections known as lanes. Each lane contains two pairs of wires: One for sending data, the other for receiving it. The serial connection works in a similar way to a network, sending and receiving data in packets through each lane's four wires. The number in 4x, 8x, and 16x PCIe connectors refers to the

number of lanes in that PCIe slot (four, eight, and 16 respectively).

The speed of each PCIe slot is further determined by the version of PCIe supported by your motherboard: The Z390-E supports PCIe version 3.0, which means each PCIe 3.0 x4 slot can handle a theoretical maximum data throughput of 32 gigabits per second (4GB/s – gigabytes per second), or 8Gb/s (1GB/s) per lane.

How does this work out in real terms? Our X470 setup has PCIe x4 slots like yours, and his Samsung 970 Evo Plus NVMe drive benchmarks around 3.5 gigabytes per second (read) and 2.4GB/s (write). One of the reasons for this slower speed is because NVMe slots transfer data through the chipset via a PCH (Platform Controller Hub) as opposed to the CPU.

Until recently, CPUs were hobbled by the number of PCIe lanes they could handle – your i7-8086K chip supports a maximum of 16 lanes, which is enough to run your GPU at maximum speed, but leaves no room for any other devices. While it's possible to connect other PCIe devices through the CPU, this would force the GPU to run at half-speed to free up eight lanes for elsewhere.

This is why motherboards offer two types of PCIe slot: Those that run through the CPU (the Z390-E has two x16 slots for this purpose), and those that run through the PCH (the Z390-E runs an extra x16 slot, plus a x1 slot as well as the two NVMe slots). While PCH-connected slots aren't as fast as those running off the CPU, the performance trade-off is far less than forcing your GPU to run at x8, as evidenced by our Samsung EVO benchmarks. ■

Design your own microprocessor

Mike Bedford has a brilliant two-part project for learning how computers work.

Most likely, the processor in your PC has upwards of a billion transistors. Trying to get your head around the workings of such a complicated electronic circuit might, therefore, seem a daunting task. Yet helping you to understand what goes on inside a CPU is the task we've set ourselves here. The latest chips are complicated by many bells and whistles doing way more than straight "processing", so we should think of a very basic chip and take it on trust that the principles here can indeed be scaled up.

In 1971, the very first microprocessor – the 4-bit Intel 4004 – still had 2,250 transistors on board. While that might be a whole lot more manageable than a couple of billion, it might still seem to be no mean feat to understand how that worked from an electronics viewpoint.

But that this isn't nearly as difficult to understand as you might fear. The fact is that logic circuitry is created in a so-called bottom-up approach. Transistors – the fundamental electronic building block – are used to create logic gates, which are the fundamental logic building blocks. From this point on, we can forget about

transistors and see how logic gates can, in turn, be used to create more complicated logic building blocks such as decoders and multiplexers. In the next stage, these are used to create even more complicated logic elements, and this continues until we finally end up with a complete CPU. Nowhere in this process will we see more than a handful of transistors or a similar number of logic gates – what could be easier?

Logic gates

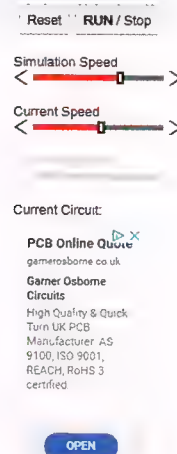
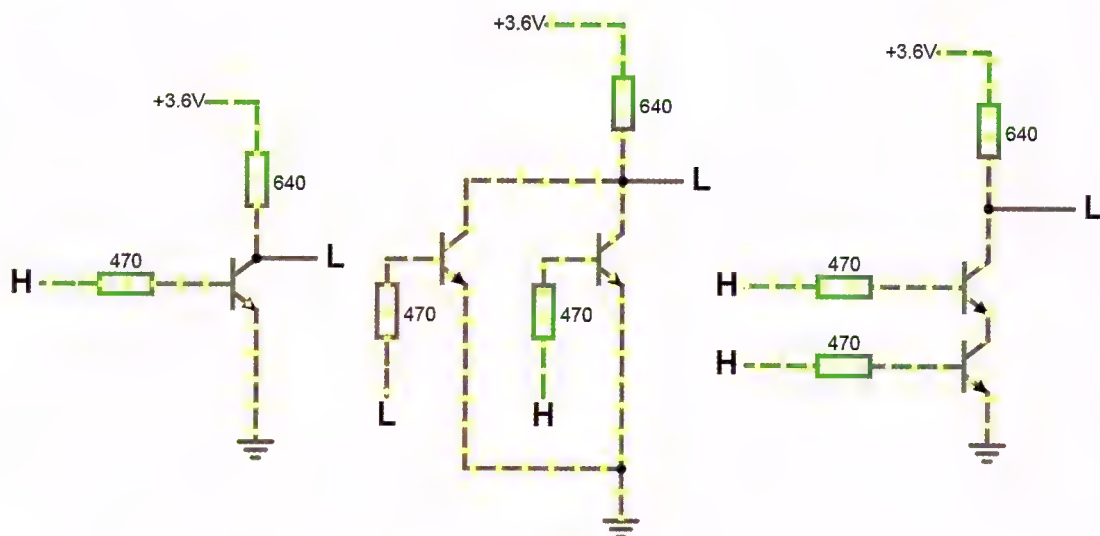
The bottom-up approach might make it easier to understand complicated logic circuitry, but learning about it with real hardware would still be a major undertaking. After all, since each transistor has three leads, and because components other than transistors are also needed, building even a basic microprocessor – like the Intel 4004 with its 2,250 transistors – would require many thousands of soldered connections. There's got to be an easier way, and there is: Simulation. Here we're going to use two simulators, one that works at the level of electronic components, such as transistors and resistors, and one that operates with logic elements.

YOU'LL NEED THIS
Internet Browser
www.falstad.com/circuit

Logisim
www.cburch.com/logisim

First of all, we're going to use an electronic circuit simulator to see how logic gates are created. It's an online utility that runs in your browser. You can find it at www.falstad.com/circuit and it's free to use. We suggest you select the full-screen view before continuing. You can define your own circuits in the simulator, but it also includes lots of sample circuits that you can try. In particular, you can find circuits for three of the most fundamental logic gates – the inverter, the NOR gate, and the NAND gate – at "Circuits > Logic Families > RTL" and then "RTL Inverter, RTL NOR and RTL NAND." As you can [Image A], we've copied and pasted them so they appear together on screen, and simplified the NOR and NAND gates by changing them from having three inputs to two.

On the display, the letters H and L, which are shown next to the inputs and outputs, refer to high voltage and low voltage – in this case 3.6V and 0V respectively, which relate to binary one and zero. This is reflected throughout the circuit by colouring wires at the high voltage in green, and those at the low voltage in gray. Moving yellow dots indicate that a current



is flowing in a certain wire.

Let's look at the inverter. When it first appears, the input is H, but to start, click it to change it to an L. Because there is no positive voltage at the transistor's base – that's the left-most of its three terminals – it's turned off in this state, which means that no current flows from its collector (top terminal) to its emitter (bottom terminal). As a result, the output is high because it's connected to 3.6V via the 640 ohm resistor. Click the input again to change it back to an H. Now the transistor is turned on and, as a result, a current flows between the transistor's collector and its emitter. The output is, therefore, effectively connected directly to 0V (the triangular three-line "ground" symbol), so it becomes low. The circuit outputs an L when the input is H, and vice versa. Putting this in logic terms, it generates a 0 from a 1 and a 1 from a 0, which is the function of an inverter.

Moving on to the other two circuits, a NOR gate means "not OR" and a NAND gate means "not AND." These can be thought of as OR and AND gates with an inverter connected to their outputs, even though they're not actually implemented that way. We trust that, as you start to play with them, it should be fairly obvious to see how they work. Slightly altered versions of these circuits, with the resistor in the emitter circuit instead of the collector circuit, can be used to implement the OR function and the AND function, which can be thought of as more fundamental than the NOR and NAND functions.

Experimenting

Although the circuit simulator includes a few logic elements among its basic components, to go much further we need to turn to a more fully featured logic simulator, so we'll use Logisim (www.cburch.com/logisim) [Image B], which runs locally under Linux. We're not going to provide blow-by-blow instructions of how to use Logisim, because there is a user manual – however, a few tips are appropriate.

To test out the various circuits that we're going to investigate, you'll generally need to connect something to all the inputs so that you can toggle them between a 0 and a 1, and connect something to the outputs to indicate whether it's a 0 or a 1. Both these requirements are fulfilled by a component called

Gates from Gates

In our look at the various types of logic gates, we restricted ourselves to gates with two inputs. However, you'll remember that the sample gates in the online simulator initially had three gates, but we removed some of the circuitry to turn them into 2-input gates – and we also saw that Logisim gates have an attribute that defines the number of gates, from 2 to 32. The fact is that logic gates can have any number of inputs, and this can be achieved at the level of transistors – or, if you only have 2-input gates, you can work at the level of logic elements, connecting those gates together to produce gates with more inputs in various ways. For example, two 2-input OR gates can be used to create a single 3-input OR gate.

Although our circuits for decoders and multiplexers used both AND gate and OR gates, just one of these two gates can be used, in conjunction with inverters, to create the other. This being the case, you can get away with just the one type of gate plus an inverter to create any other logic building blocks. Here's an experiment you could try, either in Logisim or just as a pencil and paper exercise.

Take a 2-input OR gate and connect inverters to both its inputs and output. Now see what output you get for each combination of inputs. You'll find it has become an AND gate. Doing the same with an AND gate generates an OR gate.

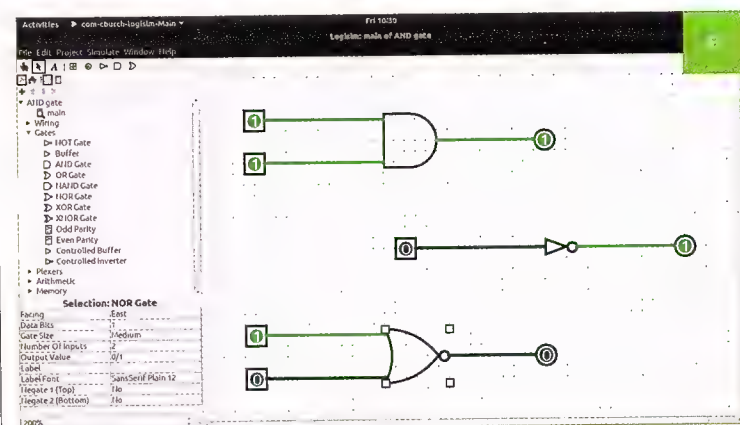
Pin, which can be found under Wiring. When you select a component to add to the circuit, a table appears that shows – and enables you to alter – that component's attributes.

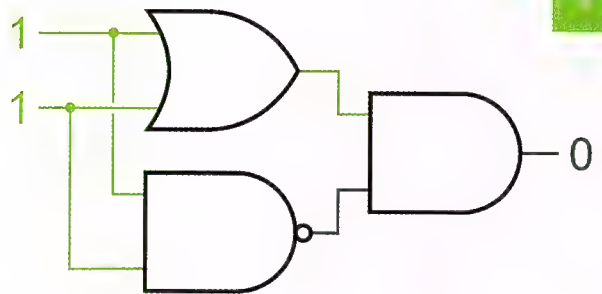
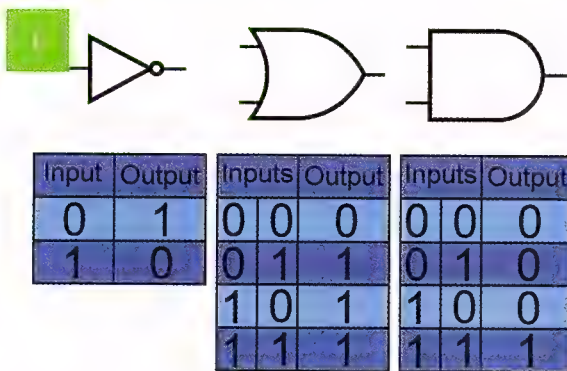
The Pin component has an attribute called Output?, the meaning of which is ambiguous. Selecting "Yes" doesn't make it an output but instead makes it something you'd connect to an output to indicate its logic state. Similarly, selecting "No" makes it something that you'd connect to an input to define its logic state. The shape changes with this selection, so remember that you connect squares to inputs and circles to outputs. Note also the Facing attribute, which is East by default, but which you'd normally want to alter to West for Pins when Output? is set to "Yes."

Note also that in addition to the 0 and 1 labels on the input and output pins, wires are coloured

dark green (almost black) to indicate 0, and light green to indicate 1. These aren't the most intuitive of colours, but there's no way of changing them, and we're confident you'll soon get used to this colour coding. Finally, to change the state of a Pin attached to an input, select the mode that allows values in the circuit to be changed by first clicking the pointing figure icon at the top left. Then just click the pin and you'll see it toggle between a 0 and a 1.

Annoyingly, however, we sometimes found the change wasn't actually implemented without first returning to the editing mode by clicking the arrow icon. Note that, if you'd prefer, you can use a LED instead of an output pin to indicate the state of an output. You'll find it under "Input/Output," and it's coloured gray for a logic 0, changing to red for a logic 1. To start, and to get a feel for the package, we suggest that you simply





try out the basic logic gates: That's the inverter, plus the AND, OR, NAND, and NOR gates. Although the symbols are different, and they now appear as single components instead of collections of transistors and resistors, you'll find that they work as expected. The default number of inputs for gates is 5, but this can be changed in the attribute table – we suggest you select 2. Note also that the Three-state? attribute should be set to "No." Indeed, if present in the attribute table, you should select this option for any components you use in these exercises. It's a useful exercise to sum up their working with a so-called truth table, which shows the output for each combination of inputs. These truth tables become much more informative with more complicated logic building blocks, but to illustrate the principle, we've provided the tables for the inverter, OR gate, and AND gate [Image C].

Finally, note that the symbol for the NAND gate is the same as for an AND gate with the addition of a circle on its output, and the same is true for the NOR and OR gates. Before moving on from gates, we really ought to take a look at the Exclusive OR and Exclusive NOR gate that we didn't see while experimenting with transistors. The Exclusive OR gate – often referred to as an XOR gate – produces a logic 1 if either, but not both, of its inputs is a 1. In other words, inputs of 0/0 and 1/1 give an output of 0, while inputs of 0/1 or 1/0 give an output of 1 [Image D]. This is our first example of how gates can be connected to create new logic functionality. From now on, we'll show just the circuit rather than a complete screenshot, even though we've confirmed them all in Logisim. Note that in our circuit diagrams, when lines meet or cross we use a solid blob to indicate that they connect, and in the case of

crossing lines, we use a short break in one of them to indicate that they don't have an electrical connection between them.

Decoders and multiplexers

So far we've seen logic gates, but logical elements get more complicated than this, as we'll see with our next two building blocks: Decoders and multiplexers.

A decoder takes a binary number as its input and produces a logic 1 on whichever of its outputs corresponds to the binary number. Decoders are more fully described by reference to the number of bits in the binary input and the number of possible outputs. Let's take the simplest – the 2-to-4 decoder – as an example, although common others include the 3-to-8 and the 4-to-16 decoders. The 2-to-4 decoder inputs a 2-bit binary number, and as a result, generates a logic 1 on just one of its four outputs, with all the others being logic 0. So, for example, if the inputs are 0 and 0 – binary 00 – a logic 1 appears at Output 0.

Similarly, inputs of 0 and 1 generate a logic 1 at Output 1; inputs of 1 and 0 generate a logic 1 at Output 2; and inputs of 1 and 1 generate a logic 1 at Output 3. In addition to the inputs and outputs we've already seen, decoder circuits often have one or more enable inputs, which need to be at a specified logic level (1 for a positive enable input, 0 for an inverted enable input) for a logic 1 to appear at any of the outputs. The best way to get a feel for how a decoder works is to try it out in Logisim. Use the circuit diagram [Image E] for a 2-to-4 decoder with a positive enable input – or, if you just want to try out one without an enable input, just ignore the enable input and use 2-input AND gates in place of each of the four 3-input AND gates. If you want to try out a 3-to-8 decoder, or even a 4-to-16 decoder, it's not difficult to build on the principles used in the 2-to-4

7-segment LED

It might not be something that you'll need to understand how a microprocessor works – indeed, this would undoubtedly be something that would be done in software – but a good exercise to help consolidate what we've seen so far is to build a seven-segment LED decoder in Logisim.

Logisim has a seven-segment display as part of its library of components, but for this exercise it's too clever. What we mean by this is that it inputs a 4-bit signal and illuminates the appropriate segments to display the hexadecimal digit corresponding to the binary number on its inputs. In other words, it already includes the decoder that we're suggesting you design. Instead, use seven separate output pins or LEDs to represent the seven segments. To make it easier to see whether your circuit is working correctly, arrange them on screen so that they're in the same position, with respect to each other, that they'd be in a seven-segment LED.

Now you need to add four input pins, and between these and the seven positioned output pins, you need to devise and add some circuitry to drive those output pins correctly. There are several ways to do this, but in general the approach involves a layer of AND gates, the outputs of which connect to a layer of OR gates, and a few inverters. You should be able to do it with 16 gates, and four inverters.

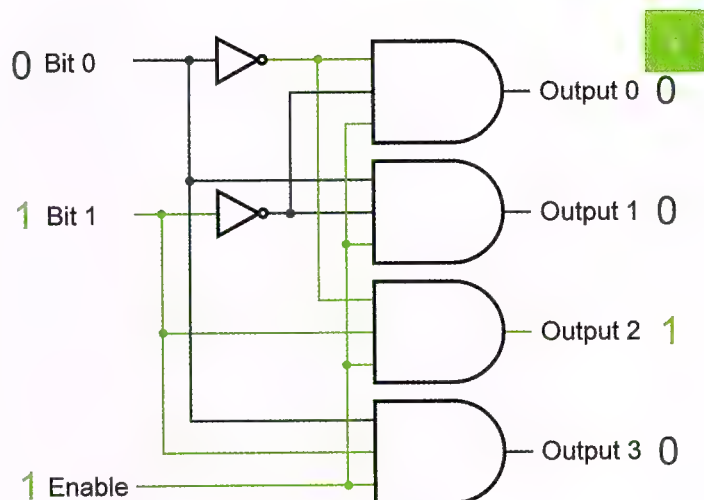
decoder, but you'll obviously need to use more gates.

If you're going to be saving your circuits for future reference, we suggest you label them to make them easier to understand in the future, rather like adding comments to code. You'll find that some components, but not all, have a Label attribute that enables you to define text that appears inside the symbol. Text can be placed at any position in the circuit: Select Text Mode by clicking on the A icon at the top left, click at any point in the circuit and type in your text.

Having seen how a decoder is implemented using gates, let's turn to Logisim's built-in decoder, which we're soon going to use to create a yet more advanced logic building block. You'll find it under Plexers, and you'll notice that you can select the number of inputs, and also whether or not it has an enable input. Logisim uses a trapezium as the symbol, but a rectangle is more common and is what we use in our circuit diagrams. The type we'll be using later is a 2-to-4 decoder without an enable, so choose 2 for Select Bits in the attribute table and "No" for Include Enable?

Perhaps unexpectedly, you'll see that the decoder only has one input instead of two; with the default attribute of East-facing, the inputs are at the bottom. That apparently single input is actually a bus, which is more than one signal combined into a single line to make the circuit diagram simpler and easier to read. This being the case, if you wire a default input pin to this bus, Logisim will complain about "incompatible widths." This means that although the bus contains the two signals that the decoder requires as its inputs, the input pin generates just a single signal. There are two possible ways to overcome this. One option is to select 2 as the number of Data Bits in the input pin's attribute table. The error message will then disappear and you'll notice that the pin now shows the values of two bits, both of which can be toggled. The alternative method is to use a component called a Splitter, which you'll find under "Wiring," and permits a bus to be split into separate signals – two, in this case. We'll leave you to figure it out, but this will enable you to connect two default, single-bit input pins to the decoder's inputs.

With decoders in the bag, we can now turn to multiplexers. A multiplexer has several data inputs,

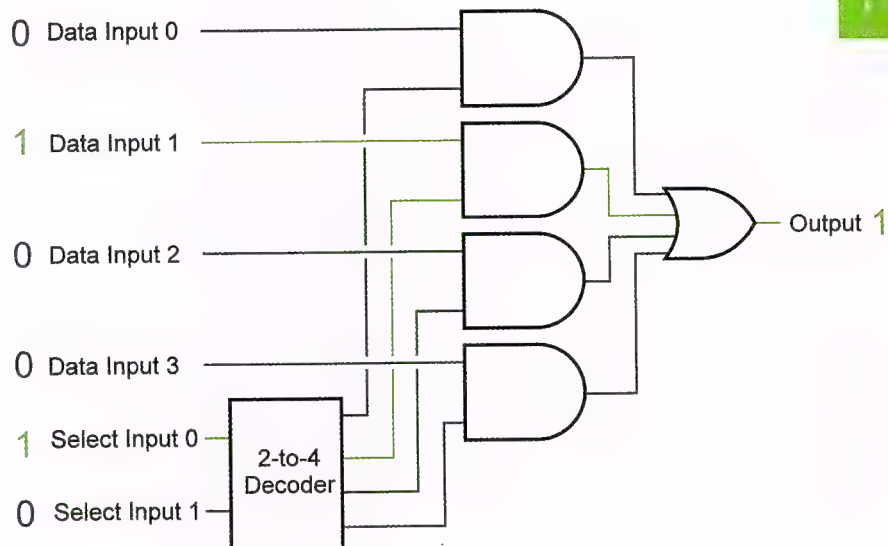


one of which is switched through to its single output, depending on the binary value on its selected inputs. Let's think about a 4-input multiplexer to provide a more concrete example of how it works. In order to select one of the four data inputs as its output, this type of multiplexer will require two select inputs to represent a 2-bit binary number. If those data inputs are 0 and 0, this will cause it to switch data input 0 to its output. In the same way, select inputs of 0 and 1 will cause data input 1 to be switched to the output; select inputs of 1 and 0 will cause data input 2 to be switched to the output; and select inputs of 1 and 1 will cause data input 3 to be switched to its output.

Now we're clear on what we want to achieve, it's time to put a circuit together in Logisim. The circuit we've provided for a 4-input multiplexer [Image F] uses a

2-to-4 decoder. While we could use the circuit that's made from individual gates, we're going to use Logisim's built-in decoder, because it'll keep things simpler and it's in keeping with the bottom-up design approach. So build the circuit shown in the circuit diagram and try it out; you should find that it implements the functionality described. The same principles apply to building an 8-input multiplexer, which requires a 3-to-8 decoder, or a 16-input multiplexer, which needs a 4-to-16 decoder.

None of this might seem to take us anywhere closer to our goal of seeing how a microprocessor works. However, we're a lot closer, because all these logic elements are essential components in a CPU – as we'll see as we conclude this in a coming issue. In the meantime, play around with gates and see what you can make! ■





MAC

Calibrate your Mac's display

Check your colour settings for more accurate photo and video viewing.

Most modern Macs look great straight out of the box, thanks to the inclusion of Retina displays that meet P3 display standards for colour accuracy. However if you're doing colour critical design work, photography, or video editing and need to make sure the colours you see onscreen

are truly true to life, then there are some handy extra steps you can take – steps that are particularly important if you're using a third-party external monitor that may have some display quirks of its own, or should you want what comes out of your printer to be a faithful

IT WILL TAKE
10 minutes

YOU WILL LEARN

How to calibrate your Mac's display both manually and by using a colorimeter

YOU'LL NEED

macOS Catalina, a colorimeter such as the Datacolor SpyderX Pro

facsimile of what you can see onscreen (and vice versa).

In macOS Catalina, you can easily check your display settings in System Preferences

> Display, where you'll find various options running under the Display, Colour and Night Shift tabs running along the top of the window. Select the Colour tab and you'll be able to check your current display profile, delete a profile or calibrate your display.

Clicking the Calibrate button opens the Apple Display Calibrator Assistant, which enables you to do things like set your display's white point, gamma and so on... Or at least it would do if most of the options weren't now hidden from view by default.

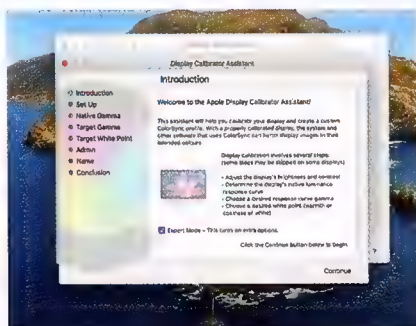
We'll show you how to regain control of those options, and also how you can calibrate your monitor more accurately by using a colorimeter – a special kind of camera that measures the colour accuracy of your display. Here we're using the SpyderX Pro (\$299, from Datacolor, datacolor.com).

ROB MEAD-GREEN



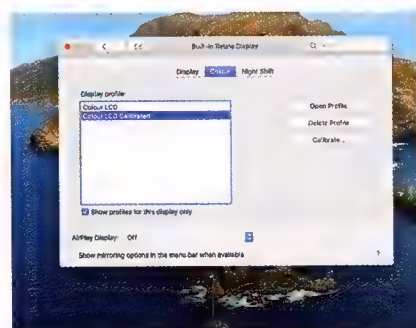
A colorimeter makes it easy to calibrate your monitor for colour-critical tasks – rechecking it once a month means your display stays on point.

HOW TO Check and change your display settings



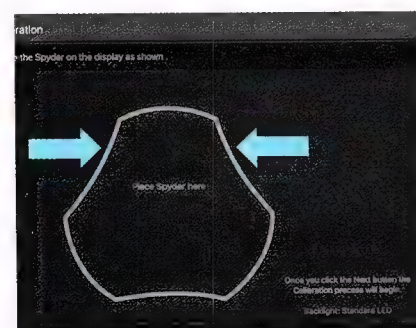
01 BE A DISPLAY GENIUS

To reveal the hidden calibration settings in System Preferences > Display > Colour, hold option when you click the Calibrate button, then make sure that Expert Mode is checked in the next window that appears. Click Continue.



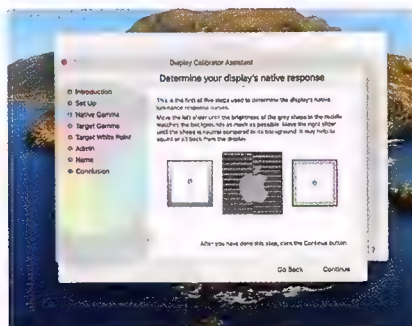
04 SAVE YOUR PROFILE

Once you've been through each step offered by the Display Calibrator Assistant, you can save your newly created profile and set it as the default if you wish. You can now use this setting as a ColorSync profile for your printer.



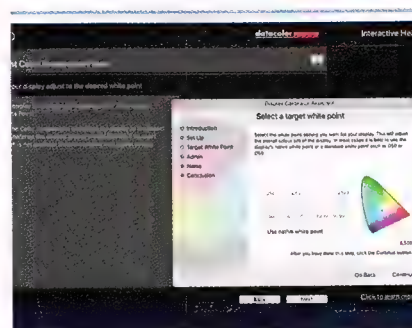
07 FOLLOW THE STEPS

Datacolor's software will now walk you through each step of the calibration process with plenty of hints and tips along the way. When you're ready, position the colorimeter on top of your display (as shown) and let the tests begin.



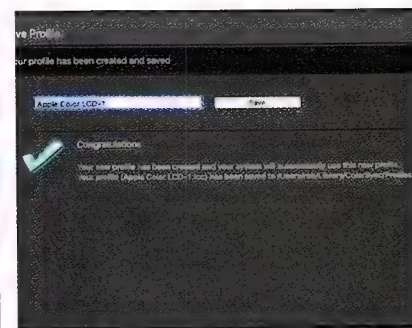
02 A NEUTRAL RESPONSE

The Display Calibrator Assistant will now walk you through five separate steps that will enable you to determine your displays native luminance response. Simply move the sliders until the Apple shape in the box is as neutral as possible.



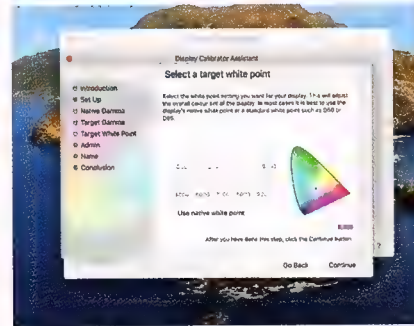
05 INCREASE ACCURACY

While Apple's Display Calibrator Assistant is handy to have, for colour-critical work, a colourimeter is essential, since it more accurately measures your monitor's various display and colour settings and adjusts them accordingly.



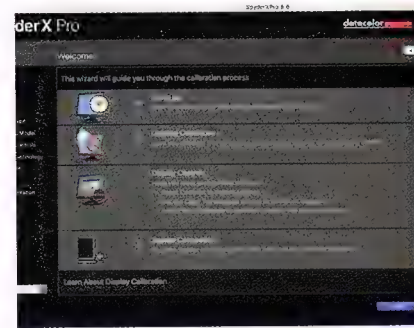
08 COLOUR CONFIRMATION

The Datacolor app will now display a series of colours in quick order, enabling the SpyderX Pro to capture an accurate picture of your monitor's capabilities. Once done, remove the colourimeter and save your new profile.



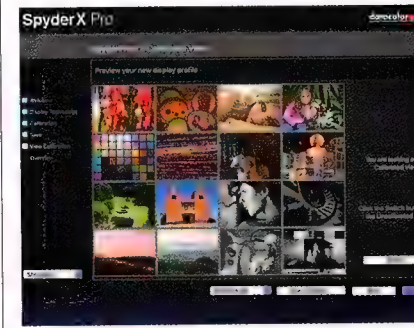
03 GAMMA AND WHITE POINT

The next two screens ('Select a target gamma' and 'Select a target white point' enable you to set the contrast and colour tint of your display. In both cases ticking the default option ('Use native white point', for example) is often best.



06 NOW MEASURE UP

To use the Datacolor SpyderX Pro colourimeter, install the software and follow the onscreen instructions - you'll need to leave your display to warm up for 30 minutes before you start testing. Plug the SpyderX Pro directly into your Mac.



09 CHECK YOUR PROFILE

In your saved profile, click the Switch button to see the difference between your calibrated and uncalibrated monitor settings. You should notice a subtle but welcome shift between the two. Be sure to retest regularly. ■



iOS

Sort out your social life

Say ciao to annoying calendar clashes with the Howbout app.

Trying to get all your friends together can sometimes feel like herding cats: when Alex and Jai are free, Arusa and Jamie aren't. If the simplest social activity seems to involve endless emails, calendar

checks and texts, you'll be delighted to discover that there's a simpler and much less annoying way to sort out your social life: Howbout.

Howbout, formerly known as Zyng, uses calendar sharing to

IT WILL TAKE
10 minutes

YOU WILL LEARN

You will learn a smoother way to make social plans

YOU'LL NEED

iPhone, Howbout app, iOS 11 or later

make your social planning much smoother. Simply connect to your friends (if they don't already use the app you can send them an invitation), enable calendar sharing and the app can automatically find out when everybody is free for real-world meetings or video chats. For real-world meets you can share the exact location of the venue so everyone knows where to go.

Share and wear

There's integrated event chat so you can talk about the specifics or avoid wardrobe clashes, and you don't have to share everything with everybody. For example, you can use Howbout to plan dates without sharing your plans with those you're not meeting up with.

You don't have to share your calendars at all if you don't want to: if you select Share Availability rather than Share Calendar others will only know whether you're available or not.

As we'll discover in this tutorial, Howbout is really simple and quick to use. If you've got a busy social life it's a huge time saver.

CARRIE MARSHALL



Howbout can use your work, social and other calendars to find times when you and your friends are free.

HOW TO: Plan social events in Howbout

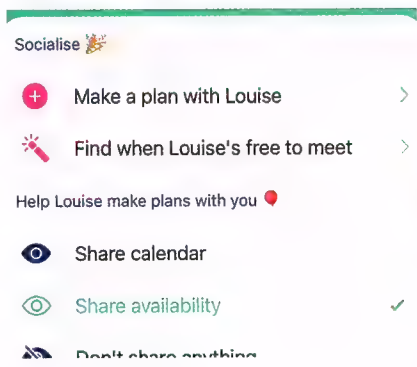
When are you busy?

Choose which calendars to link to Howbout. Don't worry, you have control over who sees what.

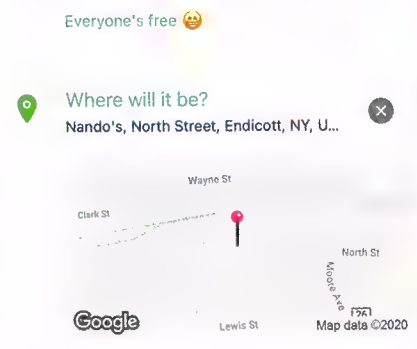
Family (shared)
Future events: Kids @ flat; Adam first da...

Personal, medical

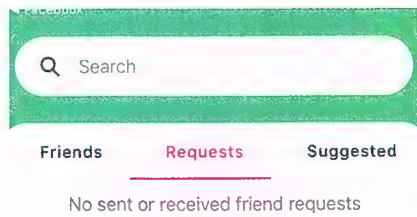
01 SET YOUR SHARING
Howbout needs access to your calendars so it knows when you're free for fun with your friends. When you first install it it'll ask which calendars you want to link to the app. Linking doesn't mean that calendar will be shared with anyone.



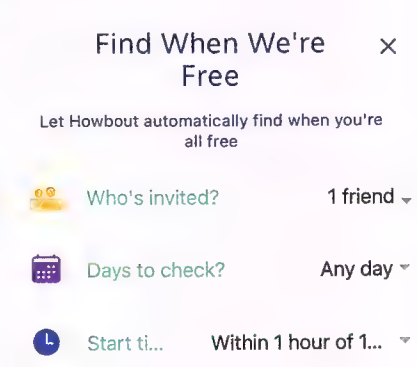
04 LIMIT THE INFO
If you don't want your friends to see every single event in your calendars, select Share Availability. This means that your friends can still check whether you're free, but not what you've got scheduled for the times you're not available.



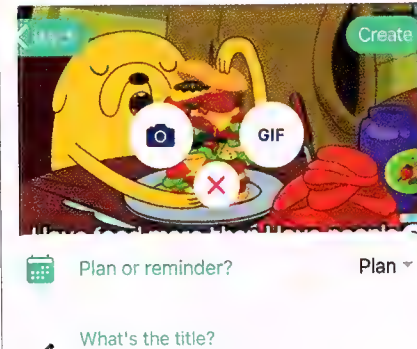
07 SHARE THE LOCATION
Once you've found a time that suits, you can decide where to go. You can do this in two ways: by picking a location from the map, or from sharing an online meeting in apps such as Zoom. The location is then shared with everyone.



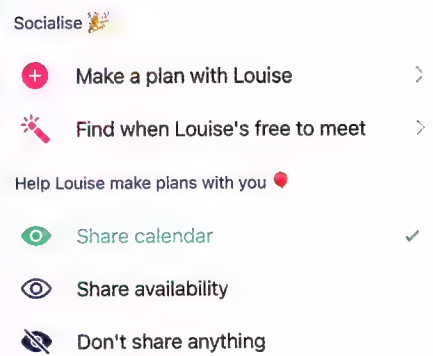
02 FIND YOUR FRIENDS
As you'd expect, the next step is to find your friends. You can do that in three ways. You can use the Nearby feature to find them if they've got the app open; you can share a link in a messaging app; or you can send an invite to their phone.



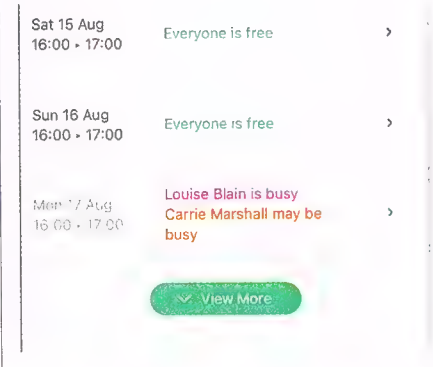
05 FIND THE FREE TIME
Finding when people are available is really fast and really easy. Start making a plan and tap Help Me Choose. Now, tell Howbout roughly when you'd like to meet up, how long you'd like to meet up for and who you'd like to meet up with.



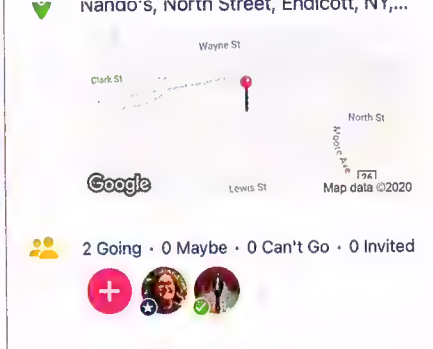
08 JAZZ IT UP
Give your plan a meaningful name so it's clear what it is. If you like, you can also change the header image for the plan by adding a photo from the camera or by choosing an animated GIF. This header is what everybody will see.



03 START SOCIALISING
When your friends install the app and accept your invitation you can plan to meet up or just check their availability, but first we need to think about sharing settings. Share Calendar will let our friends see what we've got scheduled.



06 SEE WHO'S FREE
Howbout takes your rough plan and checks everyone's calendars to see if they've got anything scheduled or marked as busy. You can instantly see who's available when, five days at a time. It looks like today is out...



09 KNOW WHO WILL GO
Once you've sent your plan, you'll see the responses - so, for example, here the green tick shows our first acceptance, so two of us are going so far. If you tap on the speech bubble icon you can start a chat with your friends about the event.

SSH replacement for persistent connections

Shashank Sharma cheerfully whistles the *Knight Rider* theme when connecting to remote machines because of the smart SSH replacement.

SSH connection is typically used to connect with remote machines. It works on a client/server model, in that the machine being used to connect to a remote machine is called a client, while the latter is the server. To establish the connection with the remote machine, you must know its IP address, as well as the username/password to authenticate the connection. Because the connection is based on IP address, any change in the IP address automatically breaks the SSH connection, turning even mild-mannered users into rage monsters.

Released under Apache license, Eternal Terminal can be used as a replacement for SSH. Its call to fame is the ability to re-establish connection to a remote machine without user intervention. This is in sharp contrast to SSH connections, which once terminated have to be re-established manually.

Eternal Terminal relies on SSH to connect and authenticate with the remote machine. So you must have SSH installed and running to

be able to connect the different machines with Eternal Terminal.

Get installing

The easiest way to install Eternal Terminal is with the Homebrew package manager. If you don't already have it installed, you can do so with a single command:

```
bin/bash -c "$(curl -fsSL
https://raw.githubusercontent.com/Homebrew/install/master/
```

You can run the 'systemctl status et' command to check the status of Eternal Terminal service.

install.sh)"

This command first downloads the **install.sh** script, and then executes it. Once the installation is complete, follow the instructions on the screen to add brew to your \$PATH.

With all that done, you can now use Homebrew to easily install Eternal Terminal with the **brew install MisterTea/et/et** command. Because Eternal Terminal operates on the client/server principle, just like SSH you'll also have to install it on the remote machine you wish to connect with as well.

If you're put off by the idea of having to use yet another package manager, fret not! Ubuntu users can install Eternal Terminal from a PPA while Arch and Fedora users can use the software repositories to install it. Apart from instructions on installing it on these distributions, you'll also find directions to install Eternal Terminal on Debian and openSUSE as well as building it from source on the project's website.

On the server machine – that is, the remote host you wish to connect with – ensure that the Eternal Terminal service is active. Depending on your distro, you might have to run **sudo systemctl enable --now et** to activate the Eternal Terminal service on the remote machine.

```
1:1 ~ + [ Tmux: linuxlala@playground:
1: linuxlala@playground: ~
linuxlala@playground:~$ systemctl status et.service
● et.service - Eternal Terminal
   Loaded: loaded (/lib/systemd/system/et.service; enabled; vendor preset: en
   Active: active (running) since Wed 2020-09-02 16:49:00 IST; 8h ago
     Main PID: 1044 (etserver)
        Tasks: 10 (limit: 13995)
       Memory: 3.6M
          CGroup: /system.slice/et.service
                 └─1044 /usr/bin/etserver --daemon --cfgfile=/etc/et.cfg

Sep 02 16:48:58 playground systemd[1]: Starting Eternal Terminal...
Sep 02 16:49:00 playground systemd[1]: Started Eternal Terminal.
Sep 02 19:30:59 playground systemd[1]: /lib/systemd/system/et.service:7: PIDFil
Sep 02 19:31:21 playground systemd[1]: /lib/systemd/system/et.service:7: PIDFil
lines 1-13/13 (END)
```

Free ports will save us!

Depending on the distribution running on your remote machine, you might not be able to create an Eternal Terminal session when you first run the **et** command.

If you encounter a **Could not reach the ET server: <ip address>:[port] error**, this means that the remote machine doesn't allow incoming connection on the specified port.

You can either change the configuration to use a port, which is open for use, or alternatively open a port for Eternal Terminal. How you do this will depend on the distribution and the firewall utility. For instance, Fedora users can open a port with the **sudo firewall-cmd add-port=2022/tcp** command. You can list all open ports with the **sudo firewall-cmd --list-ports** command.

If you're using UFW however, such as on Ubuntu, you'll have to run the **sudo ufw allow <port number>** command to open the specified port. You can then run the **sudo ufw status verbose** command to confirm that the specified port is now open.

Should you encounter any other problems with Eternal Terminal, you'll likely find answers in issues section on the GitHub page. It's a popular project and many common issues, such as lack of colours in the output of **ls** command and X11 forwarding workaround have already been addressed and closed by the developer.

QUICK TIP
You can run the 'who' command for a list of all the users currently logged into the machine. It'll display all the users connected whether through ssh, Eternal Terminal and so on. The 'w' command provides the same information, and more, but presents it differently.

Make a connection

Once this is done, you can connect to the remote machine in much the same way as you would using ssh. The syntax of the command is: `et username@[<ip address>]:<port>`. By default, Eternal Terminal uses port 2022. The essential configuration, such as the port number, for Eternal Terminal are stored in the `/etc/et.cfg` file. Refer to the box (facing page) if you can't connect to the remote machine and receive a `Could not reach the ET server: <ip address>:<port> error`.

When connecting to a remote machine, you only need to provide the port number if you've changed the configuration and opted to use a different port number than the default. Additionally, if no username is provided, the tool uses the current username on the host machine to connect with the remote machine:

```
linuxlala@localhost:~$ et
linuxlala@192.168.0.9
The authenticity of host
'192.168.0.9 (192.168.0.9)' can't
be established.
ECDSA key fingerprint is
SHA256:ovbASZs2/
xb44fCzxiegocpF3ZYDL/
g3Agtmefh3G6k.
Are you sure you want to continue
connecting (yes/no/[fingerprint])?
yes
linuxlala@192.168.0.9's password:
linuxlala@playground:~$ exit
logout
Session terminated
linuxlala@localhost:~$
```

Eternal Terminal uses SSH for handshaking and encryption, and if you've ever used ssh to connect to a remote machine, the output generated by the `et` command above would seem familiar.

When you first connect to a remote machine with Eternal Terminal, the host machine gets a ECDSA key fingerprint. You'll be asked to confirm if you wish to continue connecting to this remote machine. If you answer 'yes', this key is stored in the `~/.ssh/known_hosts` file. When connecting to a remote machine, Eternal Terminal consults this file as a way of identifying the remote machine. The key is also used to encrypt the data transmitted between the machines. You won't be prompted to confirm the identity of the remote machine if its key is stored in the `~/.ssh/known_hosts` file.

To check the ssh key on the remote machine, you must run the `ssh-keygen` command:

Instead of creating multiple connections to perform different functions, you can use Tmux on a remote connection.

```
$ ssh-keygen -l -f /etc/ssh/ssh_
host_ecdsa_key.pub
256 SHA256:ovbASZs2/
xb44fCzxiegocpF3ZYDL/
g3Agtmefh3G6k root@playground
(ECDSA)
$
```

As you can see, this key is a match for the key fingerprint as provided by Eternal Terminal when trying to establish the connection with the remote host.

You can terminate the connection to the remote machine by typing `exit` or pressing `Ctrl+D`. This is yet another overlap in functioning between Eternal Terminal and SSH, but that's to be accepted since we've already mentioned that Eternal Terminal relies on SSH to establish connection to remote machines.

Apart for the change in the bash prompt, Eternal Terminal itself doesn't produce any output or otherwise inform you when it successfully establishes connection with a remote machine. It similarly doesn't provide any information about poor connections, or even when the connection is lost entirely, such as when the remote machine is disconnected or powered off.

As long as you're connected to the remote machine, Eternal Terminal produces instantaneous results for all commands and operations you execute. However, if the connection is lost, such as when the remote machine's IP address is changed or if the remote machine is hibernated, then whatever you type on the screen is no longer shown in the terminal. In fact, the terminal will appear to be non-responsive. However, Eternal Terminal remembers all the keystrokes made during this

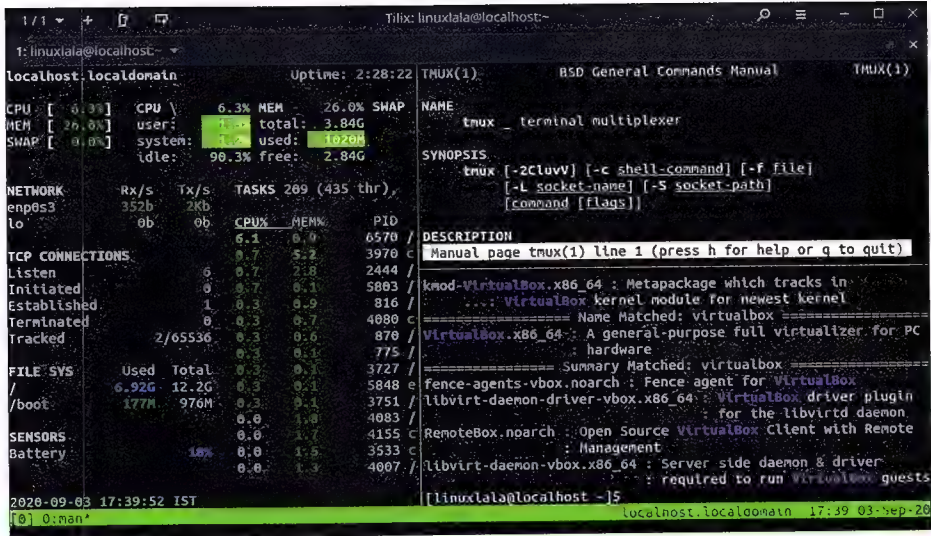
period, and executes them in order once the connection is re-established.

The project achieves this feat by implementing a special layer between the application and TCP layer. We can't cover the functioning of this layer in detail due to space constraints, but if you're interested, you'll find a primer on how Eternal Terminal works on its website.

The ability to reconnect automatically only works if the connection is terminated at the remote machine. If you restart the host machine while connected to the remote machine, the Eternal Terminal session isn't killed automatically. Instead, such Eternal Terminal sessions are referred to as orphans, and there's no way for you to connect with such orphan sessions. Your only recourse is to establish a new connection with the remote machine. When you make a new connection, the orphaned connections aren't terminated automatically and will persist until you manually kill them. You can do so by using the `-x` command option:

```
$ et -x linuxlala@192.168.0.9
This command kills all
orphaned sessions and establishes
a new connection with the remote
machine.
```

Eternal Terminal is often compared with alternatives such as Mosh. While the latter also boasts of the auto-reconnect feature, Eternal Terminal additionally supports scrolling, which means that you'll be able to go back and forth and review the generated output on the terminal screen. ■



Native Pi gaming with the classics

Christian Cawley is playing *Doom* and other games on his Raspberry Pi without emulation.

The Raspberry Pi Camera is great fun to play with, and in this tutorial we're going to use the camera with a push button that will choose a random filter for the image. We'll be using the Bash terminal as our programming language, which is a great way to introduce the powerful scripting language.

Hardware setup

The Raspberry Pi Camera now comes in many different variations, and they all connect to the camera port of the Raspberry Pi, located just behind the Ethernet/USB ports. Open the camera port by gently lifting the plastic lock upwards, then insert the ribbon connector with the blue tab facing the USB/Ethernet ports. Close the lock on the connector and give it a very gentle pull to make sure it's in place.

Power up your Raspberry Pi and then go to Preferences > Raspberry Pi Configuration. Under the Interfaces tab click the Enable button for the Camera. Then click OK and reboot the Pi.

With the Pi rebooted we'll now test the camera, so open a Terminal and type the following command to take a quick picture:

```
$ raspistill -o test.jpg
```

A preview window should appear, giving us five seconds to frame the shot before the image is

saved to disk as test.jpg. We can take a look at the image using the file manager. If there are any problems, go back and check that your camera's properly connected and that the camera interface is enabled.

On the breadboard, place a button so that it sits across the central slot. There should be two legs on either side of the board. On one side of the board only, insert two jumper wires so that they're in line with the legs. Place the other end of the wires on the GPIO. One should go to 3.3V which is pin 1, located at the top left of the GPIO connector. It's the pin nearest the SD card slot. The other wire connects to GPIO17, located five pins below pin 1, on the same column. Please see the diagram (facing page) for visual confirmation.

Go to the main menu and select Programming > Geany. Create a new file called random-art.sh and remember to save often.

We'll be using Bash to write the code for the project. Bash is a scripting language and it can be used as a quick and easy tool to create a project. We start by telling the code where to find the Bash interpreter:

```
#!/bin/bash
```

The next two lines use `echo` to write a value to a file. In this case it'll enable GPIO17 for use, and then set the direction to in which

The power of raspistill

Typically we would use Python with the Raspberry Pi Camera, but as proven in this tutorial, `raspistill` is a powerful and useful tool for projects that need just a quick solution. We've had a look through `raspistill`'s man page and found a few useful switches...

- To quickly take a pic and save it as image.jpg. This is mainly used to test the camera: **\$ raspistill -o image.jpg**
- Take pictures in low light. Note that this will slow the frame rate: **\$ raspistill -ex night -o night.jpg**
- Change the quality and resolution of the image, with 100 being the best quality: **\$ raspistill -w 640 -h 480 -q 50**
- Set the opacity of the preview window. This is useful when using the camera and it encounters a problem: **\$ raspistill -op 128**
- The final option uses the timelapse switch to auto generate a timelapse that lasts 30 seconds. A picture is taken every two seconds. The **%04d** tells the command that we wish to create a four-digit file name for each image: **\$ raspistill -t 30000 -tl 2000 -o image%04d.jpg -ex night**

will turn GPIO17 into an input pin with the default value of 0 (off). When the push button is pressed, the value of GPIO17 changes as we connect that pin to the 3.3V. So the default 0 (off) changes to 1 (on):

```
echo "17" > /sys/class/gpio/export
echo "in" > /sys/class/gpio/gpio17/direction
```

Moving on and we need to create an array that will store all 20 of the filter options. Arrays are data structures that store data using an index that starts from zero to determine the position of the item. Each item in the array has a position and we can retrieve items from the array by using the name of the array and the index number. If you're a Python coder, arrays are known as lists. The first six items are:

```
array[0]="none"
array[1]="negative"
array[2]="solarise"
array[3]="sketch"
array[4]="denoise"
array[5]="emboss"
```

More filters add artistic flair.



Use the filters to randomly create a photo that belongs in an art gallery, displaying an exhibition on pop art.

Oils, watercolours, film and graphic pen create striking images:

```
array[6]="oilpaint"
array[7]="hatch"
array[8]="gpen"
array[9]="pastel"
array[10]="watercolour"
array[11]="film"
array[12]="blur"
```

The final filters for the array create images with bright colours, low colour posters and washed-out colours.

```
array[13]="saturation"
array[14]="colourswap"
array[15]="washedout"
array[16]="posterise"
array[17]="colourpoint"
array[18]="colourbalance"
array[19]="cartoon"
```

Next, create a variable called "size" that stores the output of a command. This command will return the number of items in the array. Using the { } brackets around the command means that we're only interested in the output of the command.

```
size=$(#array[@])
```

To constantly run the code we use a while true loop. Anything inside the loop will be run over and over until we exit from the code.

```
while true; do
```

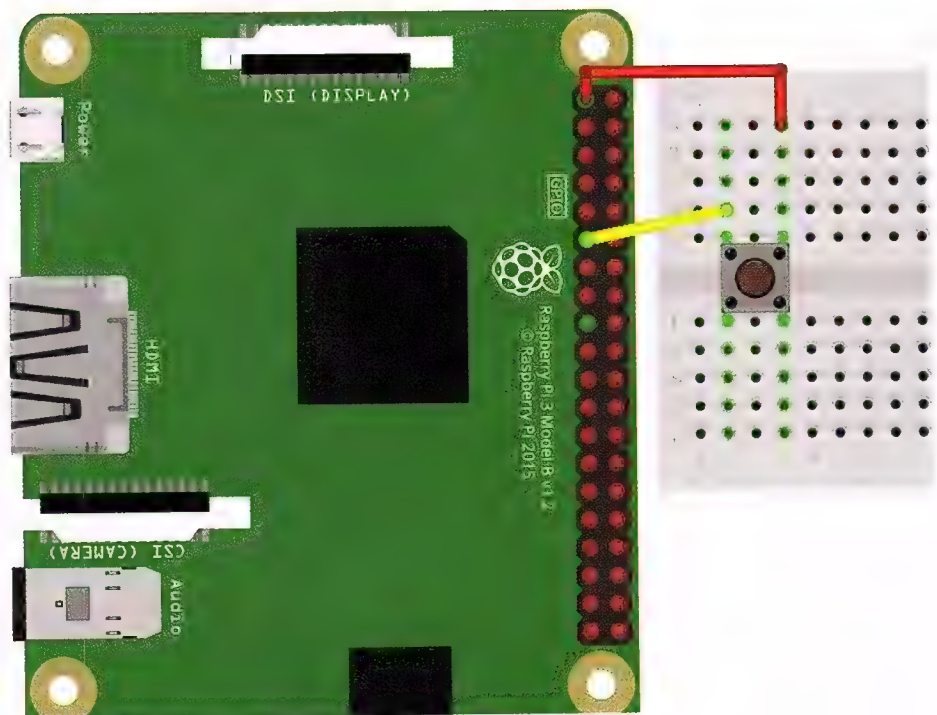
Inside the loop the first step is to generate a random number between zero and the number of items in the array, 20 in this case. We do this by creating a variable, index and storing the output from a random number generator that uses the value of size as a limit. Note that we've indented the code inside of the loop by one space, to help identify that the code is in the loop.

```
index=$((RANDOM % $size))
```

To print the name of the selected filter we echo the item stored in the array at the randomly selected index:

```
echo ${array[$index]}
```

The button connected to GPIO17 has a default state of 0 (off), but when pressed it's connected to the 3.3V pin, causing the state to change to 1 (on). To see this change we need



Just a button connected to two GPIO pins via a breadboard is an ideal way to introduce electronics via a quick hit of fun.

No this isn't a misprint, this is the low-res black and white "gpen" switch in action. Now anyone can be in a 1980s pop video!



QUICK TIP
The Raspberry Pi Camera is quite delicate. Always ensure that the Pi is turned off when inserting or removing the flat flex cable. The blue tab should face the USB/ethernet ports and be held securely in place.

to create a variable, data that will store the output of checking the value of the GPIO pin.

```
data="$(cat /sys/class/gpio/gpio17/value)"
```

A conditional test is used to check the contents of the data variable. If that value is "1" then two lines of code are activated. Otherwise the code keeps looping:

```
if [ $(data) = "1" ]; then
```

The two lines of code create a new variable, TIME which stores the current date and time in year, month, day, hour, minutes and seconds format. This variable is then used with the next line to create the filename using the -o switch. The filter used for the image is set using the randomly chosen index value from the

```
array.
```

```
TIME=$(date +"%Y-%m-%d_%H%M%S")
```

```
raspistill -ifx ${array[$index]} -o $TIME.jpg
```

The final two lines of the code will end the if conditional test, and then end the while true loop:

```
fi
done
```

Save the code and open a terminal. In the terminal use the following command to make the file executable:

```
$ chmod +x random-art.sh
```

To run the command type the following

```
./random-art.sh
```

and press the button when you're ready for an arty photo. Say cheese! ■

Ten no-cost PC upgrades

COVID has us all watching our pennies – but that doesn't mean you can't upgrade your PC. Darren Yates gives his top-ten upgrades that won't cost you anything.

In my book, PC upgrades are all about gaining more performance, more speed. But in a COVID world where we're all watching our spending, not every upgrade has to cost you money. These ten tips help keep my PC running at full-tilt without spending a cent.

01 Clean your PC

Unless you work in an ISO 14644 cleanroom, chances are good your PC will have attracted dust, even if it has a filter. Dust on your CPU and GPU coolers reduce their efficiency and drop the cooling of those components. For your CPU and GPU, reduced cooling inevitably leads to reduced performance as temperature limits are reached sooner. Always first remove the power from your PC and where possible, remove the CPU heatsink/fan and video card cooler before you begin (don't lose the screws). Clean carefully with a damp (not wet) cloth, then dry and replace. Don't remove the thermal paste on the heatsink underside unless you have replacement available.

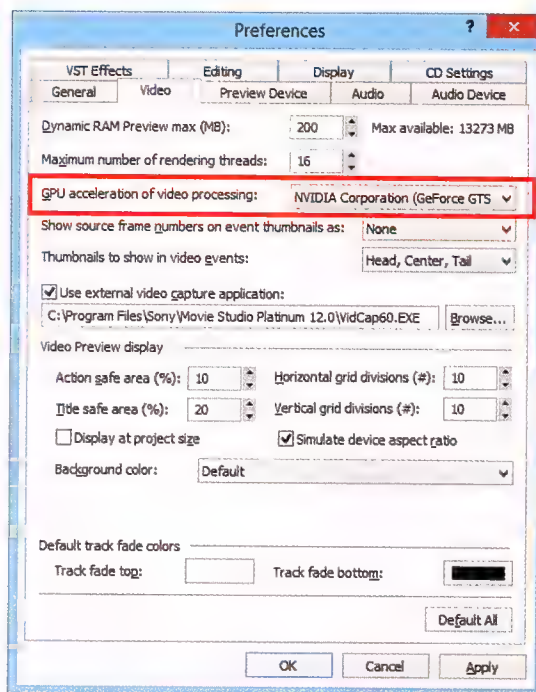
02 Clean up your drives

If you've been using an SSD as

your OS drive and using it for more than 12 months, chances are also good that it's clogged up with orphaned and unnecessary files. Use a good file cleaner to remove unnecessary files. SSDs don't last forever and wear-leveling requires the SSD to shuffle files around, even files you no longer need. Ultimately, the less junk files on your SSD, the less it has to move around and the longer it will last. Many older SSDs will also now be nearing their end-of-life, so if you haven't, now is a good time to begin your regular backup regime – before the SSD kicks the tin.

03 Don't use your SSD for media storage

For many of the same reasons, if you have a dual-drive SSD/HDD system, avoid storing media files on the SSD and keep them for the HDD. Media files – even Blu-ray rips – do not need super-fast storage. Your PC's perceived speed is as much about the latency of its storage as it is the speed of its CPU, so keeping your SSD clean to run your OS as efficiently as possible will help



Apps won't always switch on GPU-acceleration, so check the settings first.

ensure you get maximum performance from it.

04 Trial new apps using virtualisation

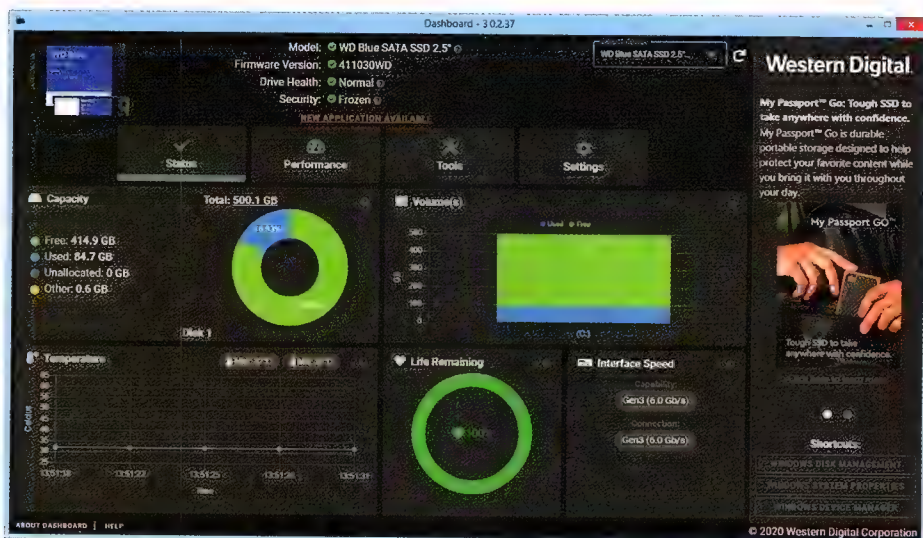
Windows often suffers from orphaned files that always seem to get left behind when you uninstall apps. I use a virtual machine (VM) to test new apps I'm not sure about – that way, my host (real) Windows machine can stay clean and I can just delete the VM when it gets stale. A virtual-machine is like having a new computer run as a software app on your PC – you can install a new OS, apps and it runs like a separate computer. It uses real storage, real CPU and real RAM but sits as files on your real PC you can remove quickly and easily. It's also a great way to have a dual-OS system without having to muck around with BIOS-level dual-booting. VMware Workstation Player and Oracle VirtualBox are free and get my tick-of-approval.

05 Choose apps with multi-CPU/GPU core support

Just because you have a PC with a zillion CPU and/or GPU cores doesn't mean that they're in use. If

“Just because you have a PC with a zillion CPU and/or GPU cores doesn't mean that they're in use. If an app has been coded as single-threaded, then it will only use a single CPU core.”

Ideally, keep your SSD for your OS files and store media files on your HDD.



an app has been coded as single-threaded, then it will only use a single CPU core. The rest of the system may use other cores for background work, but your app won't. Apps supporting multi-core processing may also include a manual thread or core count setting. Set this to the total core count of your CPU minus one (e.g. set to '5' for a six-core CPU) to maximise performance and user interface responsiveness.

06 Recycle your old systems

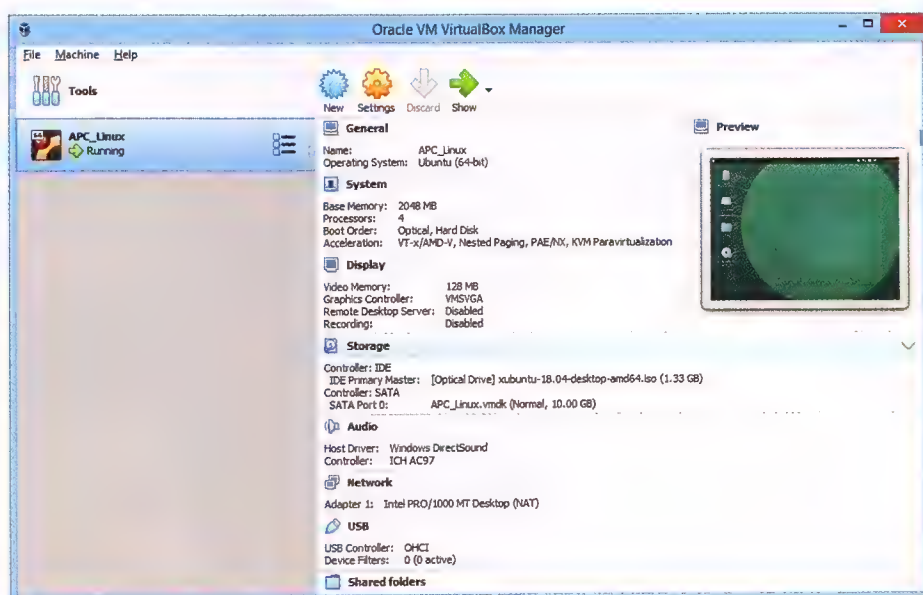
If you have an old PC or laptop impersonating a door-stop, rejuvenate it and press it back into useful service. Many retail 'home server' boxes have similar processing hardware to most Android phones, so if you have an old laptop, you can easily turn it into a file/media server. Need a new OS? Any decent Linux distro should be fine (Xubuntu is my favourite) and don't forget to backup first!

07 Update your video card drivers

Nvidia releases two sets of drivers – Game-Ready and Studio-Ready. Essentially, if you're a gamer wanting zero-day game support, you go 'game-ready', but if you're a content creator, you go 'studio-ready'. The thing is not all driver updates are smooth from day-zero, so read before you replace. Nevertheless, updates can be worthwhile – Nvidia has been known to release updates that tweak up performance of new cards, so don't assume the driver software on the supplied CD/DVD is the last word.

08 Use a leaner OS

One of the great things about Linux is that you're not stuck with one desktop environment. There are plenty to choose from. However, some are more hardware-demanding than others and if your PC is getting long in the tooth, a leaner OS desktop can help. I run a Linux distro on my Samsung Galaxy



A virtual machine is a great way to trial software and keep your drives clean.

A30 phone. Unfortunately, Xfce is too heavy for its ARM Cortex-A73 cores, so instead, LXDE gives me a leaner but faster experience. The same thing works on PCs as well – Xfce is leaner than KDE for example and LXDE is lighter and faster again. Just the thing to give older PCs a new lease on life.

09 The old 'clean install'

Yep, this is an old chestnut – but it works. A clean install is a time-sucking experience, but it's like a spring-clean that removes dead files and forces you to think about which apps you really need. Of course, you need to have your OS install media, plus all your driver and app install media ready to go, or in the case of driver software, be able to access it, whether local storage or online. And did we mention backing up?

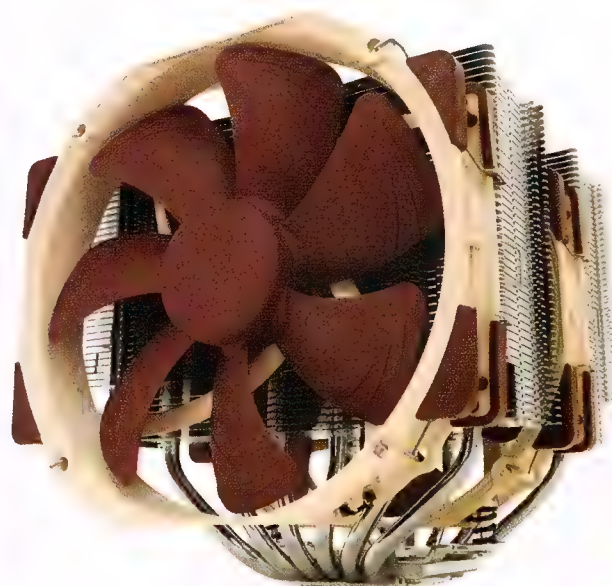
Below: An old-school hard drive is the most economical place to store your movies.

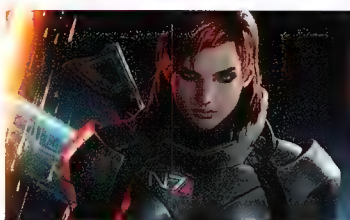
Below right: Keeping your CPU cooler clean is a must to maintain maximum performance.

10 Donate it!

With renewed focus on recycling our growing mountain of e-waste, I reckon provided your PC or laptop (or even tablet) isn't too old, it's better to donate it and give it a second life. There are many charities and organisations that will take good-quality second-hand computers, refurbish them and offer them to those who are doing it tough. If you no longer have a use for it, you can be sure someone else will. Always check with your favourite charity or organisation beforehand and never just dump your old kit at their front-door.

If you can perform any of these tips, you're not only saving money, but you're keeping your old tech out of e-waste – and that's got to be a good thing. ■





Mass Effect kicks back into gear in 2021

During its N7 Day fan celebration in November, BioWare confirmed the long-rumoured *Mass Effect Trilogy* remaster. Scheduled to launch some time in mid-2021, the *Mass Effect Legendary Edition* will bundle all three games, as well as all associated DLC. The studio hasn't shown any footage just yet, but all three games will enjoy optimisation for 4K Ultra HD.

At the same event BioWare confirmed that a brand new instalment in the *Mass Effect* series is currently in development. "A veteran team has been hard at work envisioning the next chapter of the *Mass Effect* universe. We are in early stages on the project and can't say any more just yet, but we're looking forward to sharing our vision for where we'll be going next," BioWare general manager Casey Hudson said.



Cyberpunk 2077 has been delayed until December

Studio head Adam Badowski and CEO Marcin Iwinski told fans that "the biggest challenge for us right now is shipping the game on current-gen, next-gen, and PC at the same time, which requires us to prepare and test nine versions of it" including Stadia and backwards compatible versions, and that "since *Cyberpunk 2077* evolved towards almost being a next-gen title somewhere along the way, we need to make sure everything works well and every version runs smoothly."



GAMING NEWS

Rockstar parent company buys Codemasters

Take-Two now gets *Dirt*, *F1* and more.

Take-Two Entertainment, the parent company of Rockstar and 2K Games, has acquired British racing studio Codemasters. Worth US\$980 million, the acquisition is expected to be made official in early 2021. In his statement, Take-Two CEO Strauss Zelnick celebrated the move. "We are exceedingly pleased to announce this recommended transaction with the Board of Codemasters," he said. Meanwhile, Codemasters chairman Gerhard Florin said "the Board of Codemasters firmly believes the company will benefit from Take-Two's

broad capabilities which will help propel the long term success of Codemasters."

Codemasters is one of the true mainstays of game development. Founded in 1986 by Richard and David Darling, the studio is nowadays best known for its *Dirt*, *Grid*, *F1* and *Project Cars* series (Codemasters acquired Slightly Mad Studios in 2019). The studio has also been known to dabble in action games, like *Overlord: Fellowship of Evil* and *Bodycount*, though to considerably less success.

The Medium has been refused classification in Australia

It's the next game by the studio responsible for *Layers of Fear* and *Observer*.

The Medium is the next psychological horror game from Bloober Team, the studio responsible for *Layers of Fear*, *Observer*, and the recent *Blair Witch* adaptation. But it may not release in Australia: a ruling on the Classification Board website indicates it has been refused classification.

'Refused classification' means the game is effectively banned in Australia, due to breaking some (yet to be specified) rule. As for why *The Medium* has been refused classification: we don't know. Since it was rated by the IARC (International Age Rating Coalition) rather than the board itself, the issue could be as simple as a data

entry error. IARC submissions are done via questionnaire "programmed with unique algorithms that assign ratings for each of the participating rating authorities which reflect their own distinct local standards about the age appropriateness of various content featured in the app."

It's not uncommon for a refused classification ruling to come good. Some studios modify their games to conform to the laws, whether globally or regionally. At the time of writing, Australians can still pre-order *The Medium* on Steam at the time of writing, though its release date has moved from December to January 28.

WARCHIEF G A M I N G

Ex-Blizzard VP Chris Metzen is starting a tabletop studio

"Dammit, I want to build things again."

Blizzard veterans Chris Metzen and Mike Gilmartin are starting their own tabletop gaming company – or more accurately, they're turning their gaming club into one.

Metzen previously served as Blizzard's senior vice president of story and franchise development, with credits ranging from creative director of *Overwatch* to artist and designer on *Warcraft 2: Tides of Chaos*. He finally retired from the company in 2016, though he has continued voicing *Warcraft*'s orcish hero Thrall since then. Mike Gilmartin was vice president of quality assurance at the company until he retired earlier this year.

Metzen and Gilmartin put together a

video message to fans where they explained the roots of their company, Warchief Gaming (which started out as a members-only gaming club in Orange County) and shared their excitement for getting back into creating games, worlds, and stories.

"We built some worlds, we created products, all the things I grew up loving," Metzen said. "Board games, tactical miniatures games, or RPGs, or these stories playing out as novels or comics or animation. I kind of want to do it all again. I want to do it smart, and I want to do it slow. I'm a little older, and a little wiser. But dammit, I want to build things again."

PlayStation boss says Sony may "bolster our in-house capability" with more studio purchases

The gaming giant is looking to expand their network in the PS5 era.

Sony has indicated that its open to getting more studios into its in-house production network. With the PS5's highly anticipated release day coming ever closer, the company's desire to expand its group of in-house studios seems to be growing.

Jim Ryan, CEO of Sony Interactive Entertainment, sat down with Reuters to discuss the company's imminent future in the wake of the PS5's success in smashing sales records previously set by the PlayStation 4. Ryan indicated that the console might not be available to all who

want it due to high demand.

With rivals like Xbox releasing new consoles of its own on the horizon and competition in the industry ever-expanding, Sony is looking to the help of its in-house development teams to broaden its lineup and make the PS5 a must-buy.

Ryan indicated in the interview that Sony intends to grow its assets organically through mergers and acquisitions. "Where we can bolster our in-house capability with selective M&A," said Ryan, "that might be possible."



Switch Pro could feature a Mini-LED display

Rumours surrounding a potential Switch Pro suggest the console could feature a Mini-LED display. Mini-LED technology is a fairly new display technology and could mean potential resolution upgrades. It could also result in improvements such as screen brightness and contrast, as well as to battery life, in comparison to the backlit 720p LCD screen in current Nintendo Switch consoles which relies on illumination from backlights.



The next *Battlefield* game will have 'never-before-seen' scale

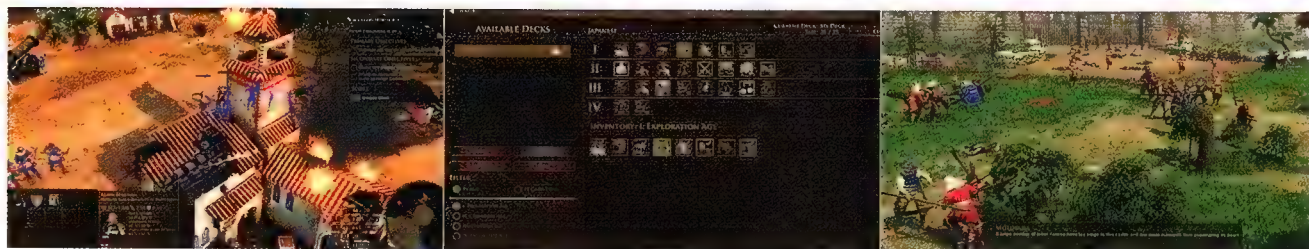
The next *Battlefield* game will launch in holiday 2021, publisher Electronic Arts has reaffirmed in its fiscal report for the second quarter of 2021. Not only that, but EA CEO Andrew Wilson reckons its going to be a big one.

"DICE is creating our next *Battlefield* game with never-before-seen scale," Wilson said in prepared remarks for EA's report. "The technical advancements of the new consoles are allowing the team to deliver on a true next-gen vision for the franchise."

He also confirmed that internal playtesting is already happening for the yet-to-be-titled installment, which follows 2018's *Battlefield 5*. The 2021 release date will mark the longest wait between a *Battlefield* installment in the series' history.

Elsewhere, Wilson reported that six new games are set to launch for "next-gen consoles" in the fiscal year 2022, meaning they'll all release between October 2021-2022. One of them is a new *Need for Speed* game developed by Criterion, which will apparently boast "astounding visual leaps." ■

GAME REVIEWS



\$29.95 | PC | ageofempires.com

Age of Empires III: Definitive Edition

The easiest way to get into this classic RTS series.

Age of Empires III comes from an era of 3D games that don't exactly beg to be remastered. It's a game where increased resolutions serve to highlight the half-baked animations that were previously hidden among pixels. So a remaster of this is like watching historical reenactments in 4K only to find that they're performed by animatronic soldiers. Yet while there's not much gained in this definitive edition, not all is lost either.

Series fans will know the drill in *Age of Empires III*: plonk down a town centre anywhere on a map, build villagers, and scurry around extracting food, wood, and gold from the earth that you use to build armies, improve your technologies, and wipe out your enemies.

There are two all-new civs in the *Definitive Edition*, both with some interesting bonuses: Sweden gets cheap mercenaries and charming wooden torps (quaint little huts) that gather resources, while Inca can garrison

military in many of its buildings and use priestesses to woo enemies over to your side.

You now only have three resources to worry about instead of four and you no longer need special buildings to store resources, cutting down on menial micro-management. There's an enjoyable card system too, which lets you set up a deck between battles, then call in supplies from your home city on a timer.

The problems with *Age of Empires III* start when you zoom in, seeing how messy things are up close. Combat neither looks nor feels great – your own units often struggle to get around each other, pathfinding is dodgy and inflexible. For a game gloating about its updated physics engine, it's strange that the physicality of its combat makes it seem like everyone's wielding weapons and armour forged from monopole north-facing magnets.

Age of Empires III remains a solid skirmish-style RTS that

would fare better were it not released shortly after a game that's so clearly Microsoft's favourite strategy baby. Where *Age of Empires II* received several expansions over the last decade, including an all-new one for the *Definitive Edition*, there are no new campaigns here beyond the base game and its two expansions released at the time. And while there are a couple of highlights in there, most notably the tale of Native American soldiers in the *WarChiefs* expansion, they don't really add up.

If you care little for single-player campaigns and are looking for a brisk RTS to play online with friends, then this is an easy path into a stalwart series and a timelessly fun strategy formula, with plenty of touches that make it easy to acclimatise to.

ROBERT ZAK

A modest remaster of a fun but flawed RTS that's stuck in its predecessor's ever-lengthening shadow.

★★★★☆



\$59 | PC, XB1, XB1, XSX, XSS, PS5, Switch | ea.com

FIFA 21

A solid if uninspiring season awaits.

EA's soccer sim has been going through the motions for years now. Ever since *FIFA 14* launched, it's been hard to shake the sense each new entry has acted as a barely reskinned version of its predecessor. It's an accusation you can definitely lay at *FIFA 21*'s feet. Though welcome improvements have been made since *FIFA 20*, this sports package could do with an overhaul.

EA deserves credit for making the on-pitch action feel less sterile and predictable. Far too often, players in *FIFA 20* felt like they were stuck on an invisible eight-directional axis – like their movement was inhibited by some unseen force. This time, movement feels more freeform, with unpredictable spaces opening up in a way that didn't happen in *FIFA 20*.

The game's physics really are stupid, though. *PES* has long held an advantage when it comes to believable ball movement, and the gap between the two soccer rivals hasn't closed in 2020. Whereas the football in Konami's series behaves like its own entity, the ball in *FIFA 21* is just... well, flat. Predictable and prone to travelling in identical fashion no

matter how hard you hit it, it often looks fake in motion.

FIFA's non-FUT headline mode has received welcome improvements with a renewed focus on training and squad management. Playing out fitness minigames in real-time ensures your players are as sharp as possible, while simming sessions lessens their impact.

FIFA's card-collecting mode has received a lot of bad press over the years, and the continuing presence of pay-to-win features feel as tone deaf as ever. FUT lets you build custom squads by opening card packs containing players and cosmetic items, like new kits or club badges. While you can unlock packs by grinding through online matches, it's quicker to buy them by spending actual money. If you feel loot boxes should go in the bin right alongside Project Big Picture, FUT will continue to leave a bad taste in your mouth.

Sadly, it's a fairly rote update that fails to meaningfully evolve the series' on-field action.

DAVE MEIKLEHAM

FIFA 21 fixes some on-pitch issues, though it stops short of giving the series the meaningful overhaul it needs.

★★★★☆



Free | PC, Mac, Linux |

bynine.itch.io/forestsecret

Forest's Secret

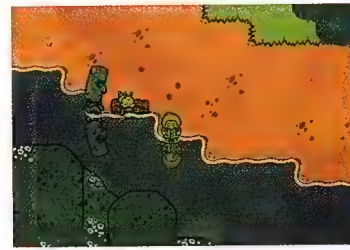
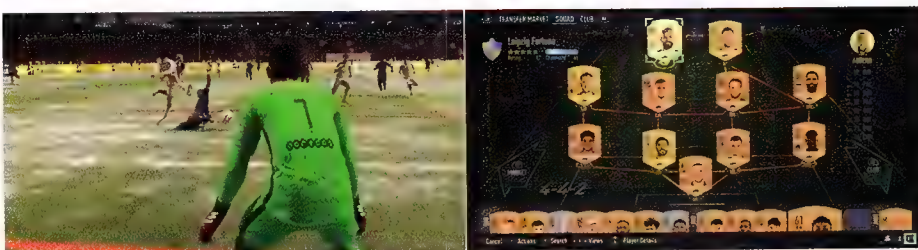
Making friends and solving problems.

You play as a traveller who has come to the forest to... well it's never really explored in great detail. But there's a power lying in a shrine in the middle of the wood, and to gain access you'll need to perform several good deeds for the people of the forest. These include helping out a ghost, growing flowers to inspire a painter, and delivering drinks in a busy cafe.

This is a game where such close inspection is rewarded. Indeed, it's the whole point. You'll follow your nose to that funny looking tree, or that suspicious patch of soil, and is that something twinkling at the very edge of the screen? Reach said suspect item and an exclamation mark will invariably appear, revealing a plot of fertile soil or perhaps a collectible acorn you can spend at the local shop. You'll unlock shortcuts as you come to know this forest like the back of your hand. It's ultimately a bit sad when the time comes to say goodbye.

TOM SYKES

A combat-free *Zelda*-like with a cast of loveable characters, in an environment that's a joy to explore. ★★★★★





Free | PC, Mac, Linux
vimislikart.itch.io

King of the Cul-De-Sac

Time for a reign check.

The sheer energy of *King of the Cul-De-Sac* puts most games to shame. There's no dull starting village, no lengthy tutorial before the inciting incident. Instead it starts with the protagonist – ten-year-old Karah – kicking a game of *Connect 4* away from some “nerds”, before declaring herself the rightful king of her cul-de-sac. What follows is a wild, kinetic journey, part interactive comic, part branching visual novel, supported by a banging rock soundtrack.

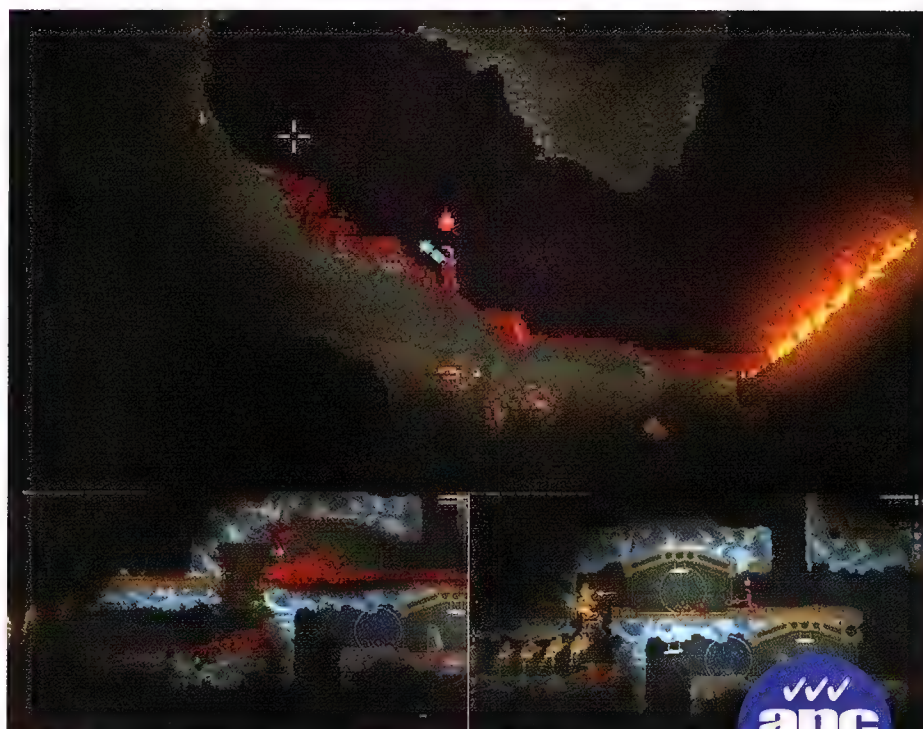
After declaring your intentions, you have to decide the sort of king you'll be: will you bring justice to the cul-de-sac, rule it with an iron fist, or try to outshine its former rulers? This is probably the biggest choice in the game, as it changes the context for your actions, setting you down one of three differing paths. Things get a bit fantastical for the middle part of the game, in which Karah battles friends and acquaintances in her quest to retrieve the crown and claim her title.

It's a game where you'll be rewarded with funny, thrilling, and occasionally even slightly affecting action.

TOM SYKES

It's a rush. In both senses of the word.

★★★★☆



\$29 | PC | noitagame.com

Noita

Destructive sorcery action in a fun, albeit messy roguelike package.

One of the core ideas in this roguelike is that you can alter your magic wands, becoming a true arcane master with clever min-maxing. But there's no safety net if your experimentation goes awry, or if you're not paying attention. When I next pointed my wand at a wall and clicked, a giant razorblade shot out, cranked a U-turn and ploughed into my wizard. Dead.

It isn't an easy game, nor is it fair, or balanced, or well-polished. But it can be absurd, brilliant fun – as long as you have the stomach for some turbid deaths along the way. Every new *Noita* seed begins with your character – a robed, Dementor-like wizard – perched at the precipice of a yawning cavern system just below your feet. Like most roguelikes, the structure of the world is consistent every time out. If you decide to traverse downwards (which isn't the only direction you're limited to), the wizard will first encounter the mines, then the coal pits, the frozen depths, a steel alien stronghold, a toxic jungle, and so on.

There is no meta progression. You will not be increasing your

health or attack power at the start of each run; there is no talent tree here to bail you out. Instead, every game of *Noita* is a self-contained universe up until the moment the warlock on screen meets their demise. Freedom, here, can only be achieved by getting good.

There are very few games that can create the sheer maelstrom of activity that *Noita* does. You're in a firefight with a shock trooper, your spell zings over his head and strikes the pile of gunpowder lurking in the shadows. Suddenly, both of you are trapped in a burning chasm, as the wooden vat containing a metric ton of oil begins to deteriorate in the flames, leading to more chaos. *Noita* desperately wants to show you what its little box of horrors is capable of. You just need to be patient enough to enjoy it.

LUKE WINKIE

Roguelike adventure and spell-building in a fully simulated, dynamic world that wants to see you dead.

★★★★☆





\$70 | PC | joinsquad.com

Squad

A game for soldiers who actually want to work as a team.

Perhaps you like to jump in and out of online shooters, and you're looking for something like *Call of Duty* to dip into a few times a month. This is not that game. On the other hand, if you're looking for something that would jump out of the monitor and slap you around the face, you'll be in oorah! heaven here. It's a game that would only hold your hand in order to crush it.

From a distance, the fundamentals appear deceptively simple. There are several game modes, but they all essentially boil down to attack and defend. The most popular modes (by far) are concerned with the comfortably familiar concept of two teams battling to capture and hold control points on the map. Success or failure is utterly dependent on your team's ability to play in the way that *Squad* intends you to.

Death comes quickly and easily in this game. Kills are usually the least important element of a match, really, and this is reflected in the score weighting. Kill an enemy and, if they're not revived, you've cost the other team a ticket. You can however lose them more tickets and/or score big points through actions such as

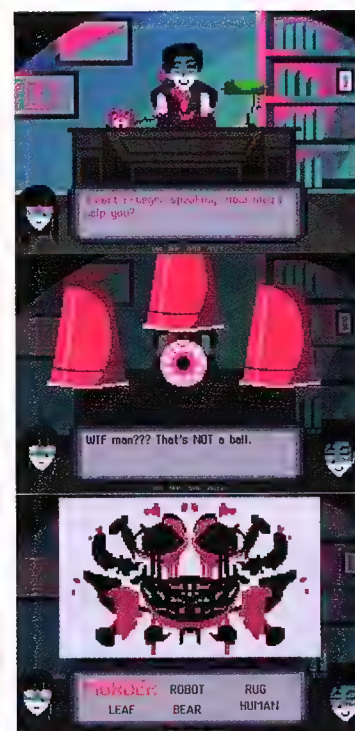
capturing and defending points, helping to build structures, deconstructing enemy structures, and reviving your teammates.

It's a game so dense with variables, I haven't scratched the surface here; but this is a review, not a wiki entry. The most important thing to understand is that this is a game that only works – and, indeed, is only actually fun – when you act as part of a team. Making a tense run across a road when you suspect there's a sniper above you, reviving and healing teammates while under fire, helping several others establish a new base... it's thrilling, intensely satisfying stuff. If only identifying enemies was as easy as in, well, pretty much any other online game I've ever played. That would turn a good game into a great one.

LUKE KEMP

A hardcore team game that forces you to play its way, but it impresses despite some unfriendly systems.

★★★★☆



Free | PC, Mac, Linux
dino999z.itch.io

Therapy with Dr. Albert Krueger

Mind games.

You've been thrown into therapy, without your consent, and with no idea how you ended up there. Rather than talking out your issues (although there is a tiny bit of that), Dr Krueger instead sets you a series of bizarre tasks: a game of ball and cups, an ink blot test that gets a little disturbing, and even a basic maths quiz. There are multiple endings based on your actions, and each offers a tiny morsel of story and worldbuilding.

For a visual novel, this is surprisingly stingy with its narrative: we're given very little information about the environment or either character. While I think it's smart to leave your readers wanting more, I could have done with a tad more world or character development to keep me engaged.

I did enjoy my first playthrough of this mysterious and amusing game, but not enough changed when I was invited to play it again. It felt like I was simply following a script, to unlock an ending I wasn't particularly invested in.

TOM SYKES ■

A simplistic battle of wits.

★★★★☆





Waterfalls of Orks
spill over the walls.

DEVELOPER RELIC ENTERTAINMENT PUBLISHER SEGA RELEASED SEPTEMBER 5, 2011 WEB TINYURL.COM/APC488WAR

Warhammer 40K: Space Marine

James Davenport read one Warhammer book and now he's that guy.

Looking back, my life divides cleanly into two distinct halves. Forget puberty, forget wrapping college, teaching high school, and moving across the US for an internship. Forget all those broken bones and all that kissing and crying. It's just pre-Warhammer 40K James and post-Warhammer 40K James now. There's old *Gears-of-War's* chainsaw-executions-are-incredibly-nasty James, and James, born again, who considers flinging around the arterial muck found within dissenters of the *Space Marine* an absolute, genuine art.

It's why a game like *Space Marine* (*Chaos Marine* sequel ASAP please), once disregarded as some action figure shooter cash-in,

hits so well even all these years later. So many of us skipped right over a classic, but if your journey was like mine, I totally understand why. I bounced off it way back in 2011, but even after reading one *Warhammer 40K* novel, it's a much more enjoyable game.

Hammer time

My first experience with *Warhammer 40K* was about a decade ago when I picked up the *Dawn of War* RTS games in a Steam sale. I had no attachment to the source material, just the vague notion that what I was looking at was clearly a *Starcraft* rip-off (little did I know the opposite was actually true). From that point, I would recognise whenever another

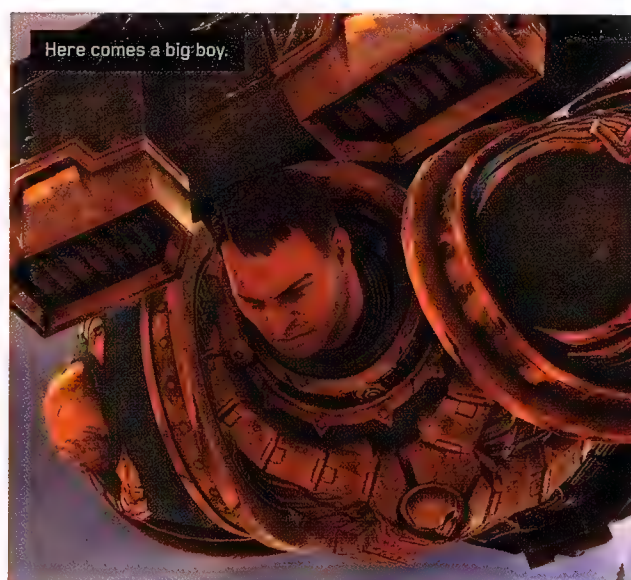
40K game was incoming, taking note of the leisure with which Games Workshop tossed the licence around. Most games were just OK from what I gathered, so *Warhammer* games started to become white noise to me.

Skip ahead to 2020: a pandemic is on, I just moved and can't really get out there and shake hands quite yet, so I've been reading just about anything a coworker sets in front of me. Simon Spurrier's 40K novel *Lord of the Night* ended up near the top of the reading list, so senior reporter Steven Messner and I decided to take the 40K plunge together. Before going in I thought *Warhammer 40K* was a thin sci-fi foundation of clichés to give the tabletop game some greater stakes, and it might still function as that for some people, but good lord, I'm not sure I've read anything so hyper violent that feels designed with the aim

"I had no attachment to the source material, just the vague notion that what I was looking at was clearly a Starcraft rip-off (little did I know the opposite was actually true)."



How Space Marines hug.



Here comes a big boy.



Loyal worms.

to joyfully bully fascists and toxic masculinity.

And like *Redwall*'s pages-long feasts in which every dish is detailed from top to bottom, texture to smell to taste, the same word counts are applied to describing what happens to a man when he's pressed through metal grating or sliced from tip to toe by impossibly sharp bladed gauntlets. Men are made into Swiss cheese, melted, chopped, baked – the violence is so grotesque and indulgent that it just becomes comedic. Paired with a sociopolitical culture that places loyalty, power, infinite capital gain at all costs, and total emotional repression at the fore, and you get galactic wars spanning millennia that are largely driven by greed and petty male bullshit. It's amazing. I don't think I've cackled so much reading a book.

With fresh eyes dripping with gore, I knew I had to revisit the pile of unplayed 40K games in my Steam library, and *Space Marine* was at the top. *Space Marine* plays on the surface of the 40K universe, rarely spending time developing characters or building out big,

important story arcs – it feels like a fan game, and even though my knowledge of the history of the 40K universe is thin, I'm a fan now, but it's clear why I glanced off so easily when it was released. Without the ability to nest *Space Marine*'s narrative in the self-aware, satirical context it's built on, there's not much to grab onto unless you're just in it to gut Orks.

MAD LADS

The four emotions of *Space Marines*



MAD



MAD AND OLD



MAD AT HELMET



THINKING 'BOUT HIM
(THE EMPEROR)

Ork-ward

So when you see an Ork explode for the first time in *Space Marine*, Relic's attempt at a 40K third-person action game, that flat, misty particle effect takes on new life if you've even dipped a toe into the extended universe. Every time Captain Titus, the protagonist in *Space Marine*, belts out praise to the Emperor or salutes a fellow marine near death in blind, horrific allegiance to some mega powerful sad boy entity, I'm hooting. Every time we cleave an Ork in two or crash down on a horde from 50 feet in the sky during a jump pack segment, I'm hollering. *Space Marine* is a fantastic, indulgent action game, but even more so if you've done the extra-curricular reading.

And now that I have a runup, I can finally appreciate what a unique game *Space Marine* actually is and how it was directly in conversation with *Gears of War* at that series' peak popularity. When waist-high cover systems were all the rage, *Space Marine* was a game that looked like *Gears of War* at first glance, but threw

Warhammer 40K's Orks don't break new ground, but they do break.



the cover system in the trash. The Space Marine is the cover in *Space Marine*, and regenerating health uses a system that feels a lot like the early inspiration for *Doom 2016*'s Glory Kills.

When your health gets low, you're encouraged to run headfirst into a crowd and perform special execution moves to get a chunk of health pack. It's a system that perfectly suits the interplay between ranged and melee combat, embracing the godly power of each Space Marine while making for a fascinating shooter based on crowd management.

Pest control

Early on, combat is a lot of thinning legions of little Ork grunts into mist with chunky weapons like a heavy bolter before the horde inevitably closes the gap and surrounds you, at which point you need to whip out the chainsword and rinse the rest away with powerful, effortless swipes. The little Orks are like bugs, but some of the



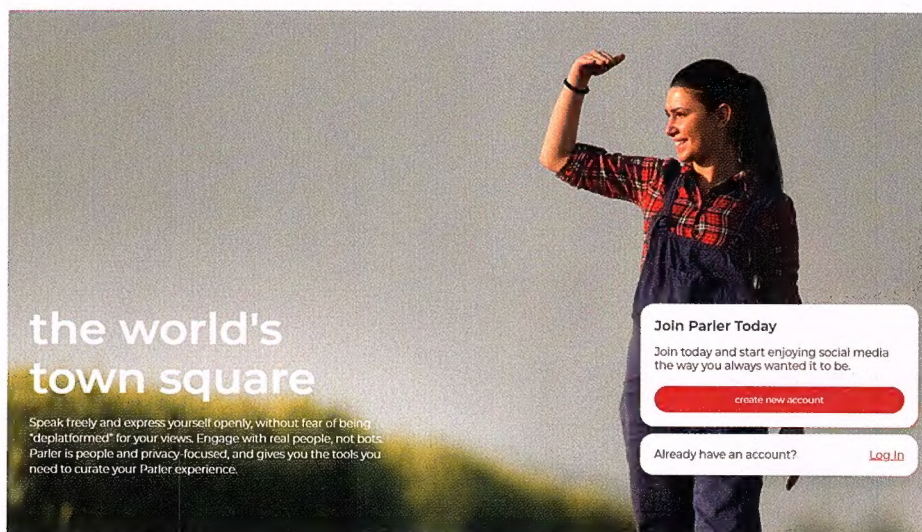
bigger enemies require well-timed dodges or attention to specific weaknesses. Later on, you'll often get rushed by a horde, then flanked by snipers from all angles while bigger enemies trickle in. Unpicking each encounter requires constant attention to enemies at every distance, and the combat supports seamless movement between shooting and melee attacks, truly supporting the fantasy of being an adept superhuman soldier who's done this dozens of times over.

Things get especially good later in the campaign when the Legions of Chaos show up. By then you've built up a pretty thorough arsenal too, including the Meltagun, a short-ranged weapon that spits out a 1,000°C beam of liquid light, or the Thunder Hammer, which stores kinetic energy in the head and releases it on impact. I'm almost annoyed with how ga-ga I go for every scrap of excess in *Space Marine*, but in these difficult times where we so often feel powerless, wielding a hammer that could flatten a tank only

feels fair.

But *Space Marine* hasn't aged perfectly. Please forgive the narrow corridors. Forgive the ugly UI that doesn't scale nicely. The environment variety and texture variety is limited, too, broadly reflecting the Brown Era of Xbox 360 and PS3 shooters. Those muddy browns and greys are pretty ugly blown up at modern PC resolutions too, though I'm sure a *Space Marine* would appreciate the drained utilitarian colour palette. All colours must bow to the Emperor.

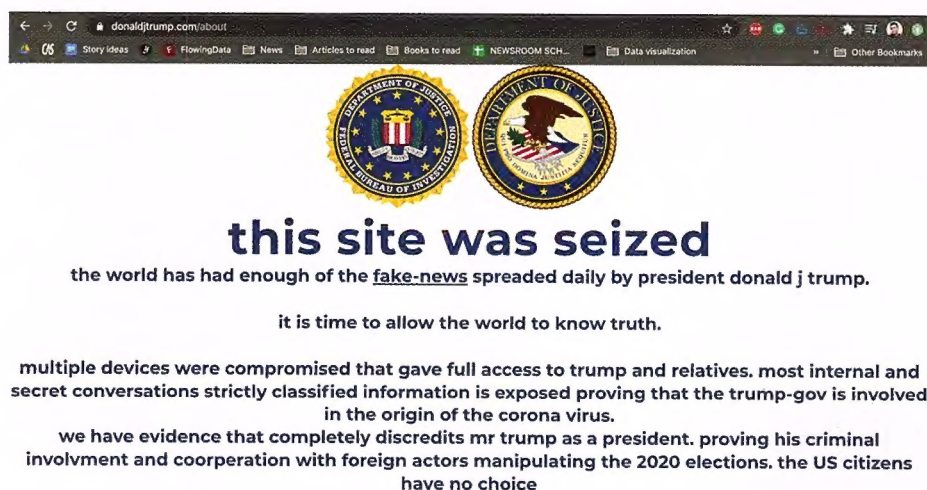
Now that I know a good portion of *Warhammer 40K* is just an excuse to watch fascists give themselves a wedgie in geopolitical slow-mo, I'm game for just about anything 40K, and *Space Marine* is a fantastic follow-up to my first book. I'm eyeballing those *Dawn of War* RTS games now, too, though maybe I'll get a few more books down first. And if you're still not sold on the universe, well, if you've ever been so mad at how cartoonish *World of Warcraft* looks that you wished you could stab it, *Space Marine* might do you right. ■



Conservatives sick of Twitter flagging conspiracy theories rush to 'viewpoint neutral' platform

Parler creates a new parlour for right-leaning opinions to run unchallenged.

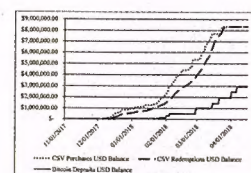
Twitter has upped its response to misinformation following the US election, flagging a number of Trump's most blatantly false claims and announcing that it will revoke its special ban exemptions for him once he leaves office on January the 20th. This more proactive response has led people who agree with the President's more dubious claims to move to platforms that are less fussy about the truthfulness of posts. Parler, a Twitter clone that describes itself as a place to "Speak freely ... without fear of being 'deplatformed'" has been topping the iPhone free app downloads charts.



Hackers defaced Trump campaign website in the lead up to election

Bitcoin scam occupied the election website for 30 minutes.

On October 20th an event in Tuscon, Arizona, Trump said "Nobody gets hacked. To get hacked you need somebody with an IQ of 197 and he needs about 15 percent of your password." So it's a little comical that just a week later hackers were able to deface the Trump campaign website and attempted to collect cryptocurrency donations through it for 30 minutes. The site was altered to look like it had been seized by the FBI, including Department of Justice seals and the message that "this site was seized the world has had enough of the fake-news spreaded daily by president donald j trump."



Microsoft engineer gets nine years for stealing US\$10 million in store credit

A Ukrainian software engineer working for Microsoft has been found guilty of stealing US\$10 million worth of store credit in a US district court. 26-year old Volodymyr Kvashuk was responsible for testing Microsoft's ordering process by making online purchases using a master account that didn't require payment. While the testing system stopped the delivery of products, it didn't prohibit the purchasing of gift cards. After collecting the gift cards Kvashuk sold them for bitcoin and cashed-out using the popular cryptocurrency platform Coinbase. The prosecutors estimate Kvashuk was able to generate US\$2.8 million after transactional losses, which allowed him to buy a US\$160,000 Tesla and a US\$1.6 million waterfront property.



Furries are hanging out in a VR Four Seasons Total Landscaping carpark

If you weren't aware, Rudi Giuliani, former New York Mayor and one of the few remaining henchmen of Donald Trump, delivered his last speech before Trump's election loss in the car park of a landscaping company, next door to a sex toy shop and a crematorium, after a White House staffer mistook the venue for the elite hotel chain. In response to this seminal gaffe, YouTuber and furry enthusiast coopertom recreated the glorious Trump-aligned car park in the social VR application VRChat. The Four Seasons Total Landscaping chat room is open and free to explore in all its chipped paint and sad poster glory for anyone with a VRChat account. ■



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